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# *SILVER BOW CREEK INVESTIGATION*

DRAFT FINAL

RESPONSES TO COMMENTS RECEIVED FROM  
ARCO COAL COMPANY ON THE WARM SPRINGS  
PONDS PHASE II REMEDIAL INVESTIGATION  
DATA SUMMARY REPORT




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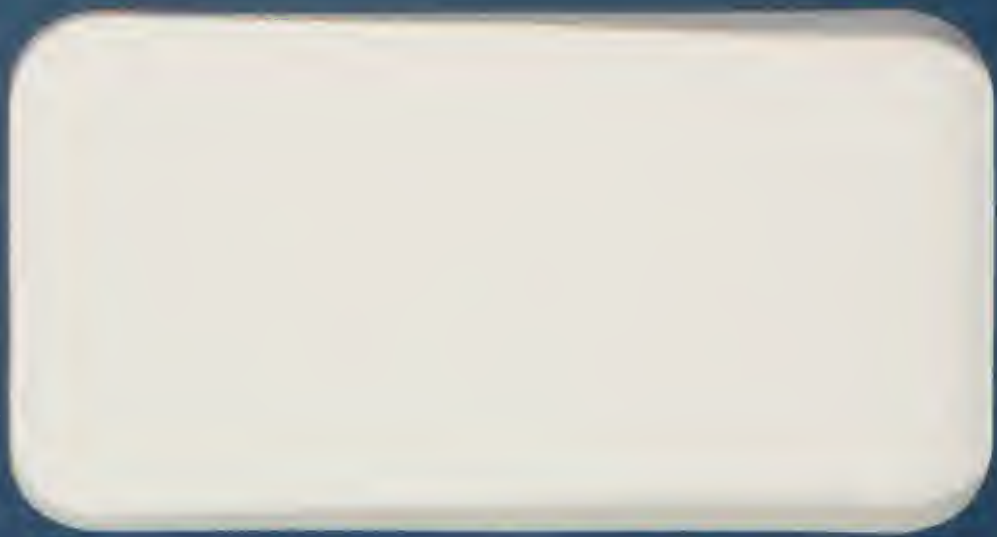
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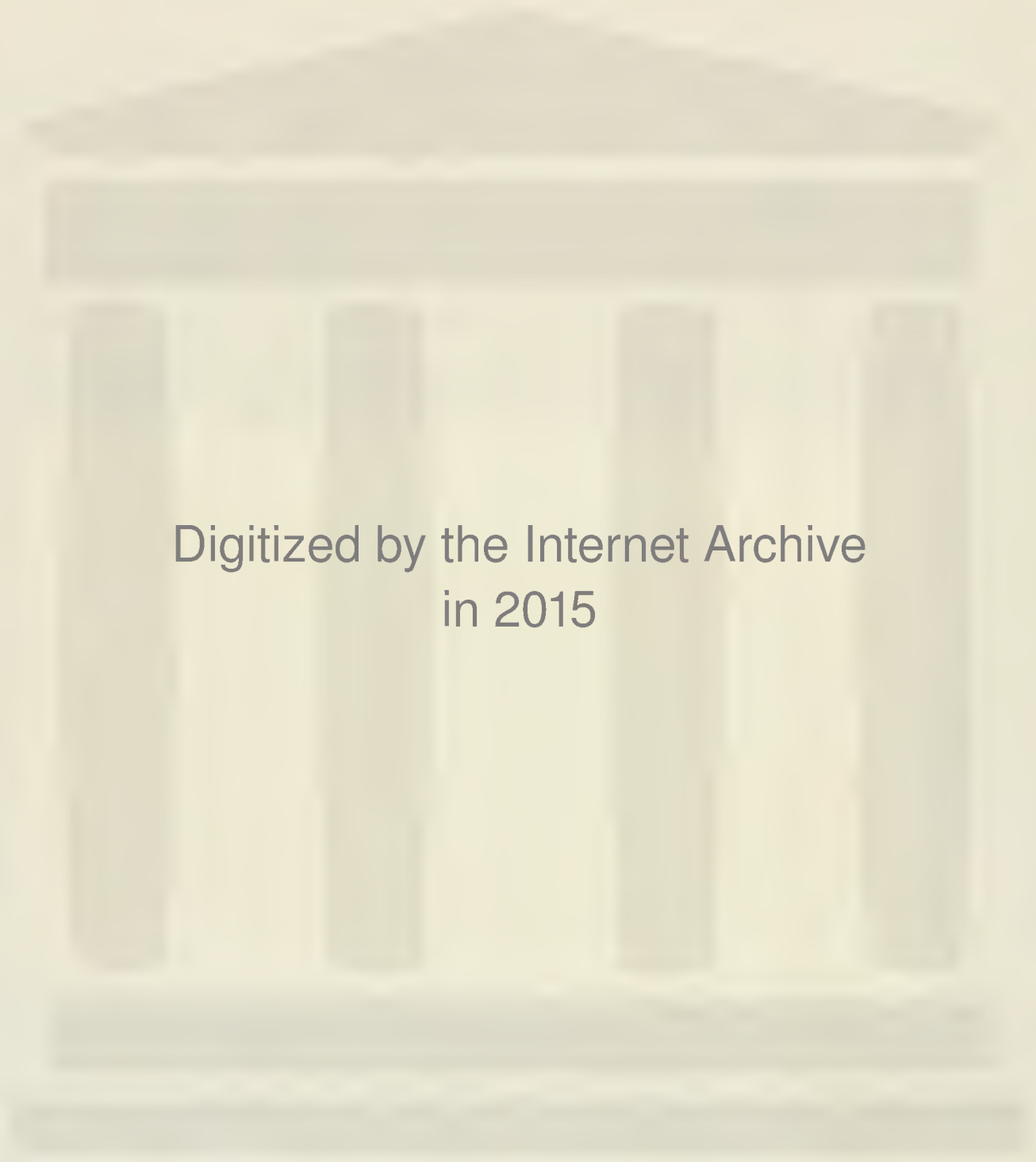
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RESPONSES TO COMMENTS RECEIVED FROM ARCO COAL COMPANY  
ON THE WARM SPRINGS PONDS PHASE II REMEDIAL INVESTIGATION  
DATA SUMMARY REPORT

Prepared for:

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## INTRODUCTION

Chen-Northern, Inc. and CH2M HILL, Inc. personnel prepared this document for the Montana Department of Health and Environmental Sciences (MDHES) to respond to comments received from ARCO (dated July 31, 1989) on the Silver Bow Creek CERCLA Phase II Remedial Investigation Data Summary Report- Warm Springs Ponds Operable Unit (Document No. SBCWSP-DS-F-R0-050589). MDHES completed a Phase II remedial investigation at the Warm Springs Ponds Operable Unit from the fall of 1987 through the fall of 1988. The purpose of the Phase II remedial investigation was to gather data to fill data gaps identified through review of the Phase I remedial investigation (MultiTech, 1987, Appendix C). The MDHES considered collection of these data necessary to support completion of a public health and environmental assessment and feasibility study at the site.

Field scientists completed four types of field investigations during the Phase II remedial investigation. These included studies of surface water, groundwater, pond bottom sediments, and exposed tailings and contaminated soils. MDHES contractors presented data resulting from these investigations in a two-volume report issued to the MDHES.

We organized responses to ARCO comments on the Phase II remedial investigation document in a manner consistent with the format used by ARCO in their comment document. We have presented ARCO comments in their entirety in italicized type. Our response to each comment is presented immediately following individual comments. We have included attachments to this response document which contain additional information and data requested by ARCO in their comments. For this reason, MDHES will not revise and reissue the Phase II remedial investigation data summary report. This response document provides and incorporates any necessary additions and revisions to the original data summary document. Collectively, the original Phase II remedial investigation data summary report and this response document will serve as the final document associated with this phase of the CERCLA process at the Warm Springs Ponds.





## 1.0 INTRODUCTION

### COMMENTS

No Comments.



## 2.0 SURFACE WATER INVESTIGATION

### COMMENTS

#### 2.1 METHODS

1. *Water samples were taken at depths generally 6 to 18 inches below the water surface. Water samples should have been taken at various depths in order to completely characterize phytoplankton population. The discussion in the RI should be expanded concerning preservation of phytoplankton samples (i.e. was formalin, merthiolate, etc. used) and the laboratory techniques utilized in determining the population should be specified. The following laboratory methods should be discussed: estimation of plankton population, concentration/dilution of samples, and quality control and calibration of microscopy. Additionally, a qualitative description of the phytoplankton found in the OU needs to be included. Plankton data should be reported on a volume-per-volume basis in addition to a numbers per milliliter basis since this form of data is more meaningful.*

Response: The purpose in completing diurnal sampling at the Warm Springs Ponds was to provide data to characterize the magnitude and timing of fluctuations in metals concentrations over a 24-hour period. A secondary purpose was to determine if phytoplankton and algae populations residing in the pond system were causing pH changes responsible for such fluctuations. The sampling program was not designed to completely characterize the algae and phytoplankton population spatially or vertically in the pond system. Collected data are suitable for determining the relationship between phytoplankton numbers and changes in pH and metals concentrations. Laboratory techniques used during this study are described in the project Laboratory Operations Plan (Document No. WSTP-LOP-F-R0-080387, August 3, 1987).

2. *Sulfide precipitation of some metals is likely to be occurring naturally to some degree within the pond system as indicated in the Pond Bottom Sediment Investigation (Section 4.3). Also, sulfide may be found in water as a result of microbial action on organic matter under anaerobic conditions; hence, it should have been included as an analyte for testing water samples in Table 2-1. Sulfide precipitation of certain metals (including arsenic, cadmium, and copper) is a possible treatment method. In addition, the ionic form of certain species such as arsenic has a great deal to do with their tendency to precipitate under conditions of varying pH. Therefore, the ionic forms of selected elements should have been included in the sample analysis.*

Response: The minimum dissolved oxygen concentration measured during the Phase II RI was 4.0 mg/l. Under these aerobic conditions, it is unlikely that sulfide would



be present. Additionally, if sulfide were present, it would most likely be below analytical detection limits. Sulfide precipitation was tested in the treatability tests and the effect of sulfide on metals removal was determined (see Appendix A-3 of the Phase II RI).

It is agreed that the ionic form of certain species does affect their removal efficiency. However, determination of the arsenic species present would have had little practical value. The highest dissolved arsenic concentration in the discharge from Pond 2 was 15.6  $\mu\text{g/l}$  and the highest total arsenic concentration was 17  $\mu\text{g/l}$ . These concentrations are below the 20  $\mu\text{g/l}$  discharge standard established in the Warm Springs Ponds ROD.

3. *An explanation of the terminology, "Depth-and-Discharge-Integrated Sample", which were collected at each site with moving water (Page 2-4) should be provided.*

Response: "Depth- and Discharge-Integrated Sampling" techniques are described in NETSOP-03 of the project field operations plan (CH2M HILL, 1987b). The technique generally involves dividing the stream cross section into four to six sections. The quantity of streamflow moving through each section is approximately equal. Samples are collected at the midpoint of each section with a sediment sampler (e.g. DH-48) by lowering and raising the sampler at a constant rate through the water column. Samples obtained from the various stream sections are then composited into a single sample. This technique insures that a representative sample is obtained from a surface water course which may be subject to stratification or line source input.

## 2.2 CHANGES TO THE PROJECT WORK PLAN

1. *Rationale for implementing changes to individual sampling sites and sampling frequencies are outlined in this section of the RI. At the top of Page 2-8, it states that sampling locations SS-20A and SS-26A were no longer sampled after the September, 1987 sampling results. The sampling results which were utilized to discontinue sampling of SS-20A and SS-26A should be discussed. These sample sites may have been used to characterize pond flow water chemistry during winter months. Additionally, sample data from these sites should have been obtained in order to permit characterization of phytoplankton populations in the ponds during the highest concentration sampling event in April.*

Response: The decision to discontinue sampling at sampling locations SS-20A and SS-26A was based on evaluations of analytical data (particularly copper and zinc) for the September, 1987 sampling event. Analytical data from sampling site SS-20A were compared to data from sampling locations SS-20 and SS-22, which are located above and below site SS-20A. Likewise, data from site SS-26A were compared to





data derived from sampling sites SS-26 and PS-12, located above and below site SS-26A. Hydrologists performing these comparisons discovered differences in metals concentrations (particularly copper and zinc) between the data groups was generally less than 5  $\mu\text{g/l}$ . There was no distinct trend to the data to suggest that metals concentrations were increasing or decreasing laterally at sampling sites included in the two data groups. As a result of this level of data analysis, project personnel decided to eliminate the two near shore sampling sites from subsequent sampling events to minimize collection of redundant data.

Project hydrologists collected samples for turbidity analysis from the outflows of Pond 3 (station SS-22) and Pond 2 (station PS-12) during late winter and early spring, 1988 to determine the timing of the spring sampling event. These data were used to determine when the greatest biomass in the pond system occurred and consequently, the timing of the April, 1988 sampling event.

2. *Sample station SS-21 should have been retained during winter sampling. The station is located at the discharge from the east decant tower. Flow and chemical data taken during the winter at this location should have been utilized to assist in determining whether or not flows are short circuiting through Pond 3 because of ice formation.*

Response: Data which characterize the differences in water quality between the east and west decant towers in Pond 3 during winter flow conditions are contained in Appendix C of the Phase I Remedial Investigation (MultiTech, 1987). Because these data were available, site investigators did not consider it appropriate to collect additional data from sampling station SS-21 during the Phase II Remedial Investigation.

3. *Sampling was not performed at location SS-27 within the pumpback discharge from Pond 1 into Pond 2 during several sampling episodes. The reasons for this should have been stated. Sample data from this site would have provided useful information for characterizing metals loading on Pond 2 from Pond 1.*

Response: As stated on page 2-8 of the Phase II Remedial Investigation Data Summary Report, sampling was not performed at this pumpback during the September, 1987 and January and July, 1988 sampling episodes because the pumpback system was not operating at the time these sampling events were completed.

## 2.3 PRESENTATION OF DATA/RESULTS

1. *This section of the RI is generally insufficient in presenting the significance of findings and interpretation of results. The reasons for the fluctuating pH values in diurnal*



*sampling events should be fully discussed. The effect of phytoplankton on the results should also be discussed.*

Response: As stated on page 1-1, the Phase II Remedial Investigation report was intended to present and summarize data collected during the study. Preliminary and cursory evaluations of collected data are offered in the report. More complete interpretations of these data were completed, as needed, in support of the draft Feasibility Study for the Warm Springs Ponds Operable Unit (CH2M HILL, October, 1989).

2. *On page 2-21, it is stated that dissolved metals are higher in the winter and are directly correlated to lower pH. In general this is true, however, it is not all inclusive for every sample site and metal (Table 2-3). This discussion needs to be expanded to explain this correlation. Additionally, an analysis should be provided to show the effects of flow on dissolved metals content and to further characterize flow through the pond on a seasonal basis.*

Response: The intent of the statement on page 2-21 was to provide a general assessment of data collected during the Phase II RI. Expanded analyses of the data (including the Phase I RI data (MultiTech, 1987, Appendix C)) were performed, as necessary, in support of the site feasibility study.

3. *The definition/meaning of the abbreviations should be footnoted on the bottom of Table 2-3.*

Response: The definitions of abbreviations used in Table 2-3 include the following:

- ♦ n -- number of natural samples
- ♦  $\mu\text{g/L}$  -- micrograms per liter
- ♦  $\text{mg/L}$  -- milligrams per liter
- ♦  $\text{mg/ml}$  -- milligrams per milliliter
- ♦ counts/ml -- counts per milliliter
- ♦ S.U. -- standard units
- ♦  $\mu\text{mhos/cm}$  -- micromhos per centimeter @ 25° C





- ♦ cfs -- cubic feet per second
- ♦ °C -- degrees Centigrade

4. *For statistical purposes, utilizing the detection limit for values reported below the detection limit will provide a conservative skew to the data. For comparison, the analysis should also have been done using zero and one-half the detection limit for values reported below the detection limit. The results with a detection limit range (zero to the detection limit) provide a more meaningful comparison.*

Response: Preparers of the Phase II RI data summary report used the detection limit in completing statistical summaries presented in the report. The data are amenable to statistical manipulation using values other than the reported detection limit for those analytical data reported as less than detection. Such analyses (e.g. use of one-half the detection limit) were completed in support of the Warm Springs Ponds public health and environmental assessment (PHEA). Statistical analyses from both the PHEA and the Phase II RI were used in preparing the record of decision for the Warm Springs Ponds Operable Unit.

5. *To meet the objective of the RI, the effects of the factors, listed on the bottom of page 2-21 (temperature, pH, dissolved oxygen, etc.), on the pond OU need to be further discussed. Also, lead is an important contaminant to be considered in the pond system. However, results for lead are generally lacking from any discussion within the report. A discussion of the effects of lead on the pond OU needs to be provided.*

Response: The Phase II Remedial Investigation report was intended to present and summarize data collected during the study. Preliminary and cursory evaluations of collected data are offered in the report. More complete interpretations of these data were completed, as needed, during preparation of the site feasibility study. Additional brief discussions of the diurnal variations of pH and dissolved oxygen were presented in the Phase II RI report on page 2-40, paragraph 3.

6. *Although it is not stated in the RI Report, it should be noted that, from a water quality standpoint, Pond 2 provided substantial benefit in removal of metals. In many cases, the increased retention time provided by Pond 2 was required to meet water quality standards. For example, chronic AWC (ambient water quality criteria) would not have been achieved by the system without the use of Pond 2 during September, April, and July for copper concentrations; and during September and January for zinc concentrations.*

Response: This statement you present was made in the Phase II Remedial Investigation report on page ES-2. However, this fact does not preclude the possibility that Pond 2 is actually a source of metals to the outflow water quality





during certain times. Because Pond 2 is relatively shallow, the possibility exists that wind-induced wave action can erode the pond bottom sediment and make the material available for transport out of the pond system. Remedial Investigation field personnel have observed such conditions in Pond 2 but no data have been collected to characterize the significance or magnitude of these events.

7. *The text mentions that sampling occurred at site 19-A during a lime addition event. Review of Appendix A-1B indicates that insufficient data were available to determine the effects of lime addition between sites 19 and 19-A during January. Since the treatability studies do not simulate actual conditions at the ponds, data indicating the effect of lime addition to the creek (i.e. pH, flow distribution, etc.) would aid in designing a lime addition facility during the feasibility study and should be included.*

Response: The purpose of obtaining samples at site SS-19A was to gain insights into the inflow conditions to the ponds during lime addition, rather than to examine the performance of the pond and the effectiveness of the existing lime feed system. The two sample points referenced in the comment (19 and 19-A) were too close together to offer much insight on overall pond behavior during lime addition. The new lime addition system that will be part of the improved pond treatment system will be designed to provide proper mixing of the lime slurry and the creek water. A detailed investigation of the current lime system would not provide any useful information.

8. *Surface waters were analyzed for dissolved, acid soluble, and total metal concentrations. Since the acid soluble extraction is less rigorous digestion than the total metals analysis, it is expected that acid soluble concentrations would be lower than total concentrations. However, data in Table 2-3 and in Appendix A show many instances where acid soluble concentrations are higher than total concentrations. In some cases, the data also show concentrations of dissolved cadmium greater than the total. An explanation of the reasons for these differences should be provided in the discussion.*

Response: You are correct in stating that total metals fractions theoretically should be higher than acid soluble fractions and that acid soluble fractions should be higher than the dissolved fractions. We recognize that some of the data presented in the Phase II Remedial Investigation report do not fit this theoretical progression. There are several possible reasons for explaining why certain data do not fit this mold:

- ♦ Average values presented in Table 2-3 may include anomalously high values for certain data included in the statistics associated with a certain type of analysis. This would cause the reported average to be higher than it would be by not including all the validated data.
- ♦ Less precision and accuracy is realized for reported concentrations near the laboratory detection limit. The percent error for samples containing low metals concentrations is much greater than for samples with relatively high



metals concentrations. Therefore, the likelihood that dissolved concentrations exceed either acid soluble or total concentrations increases.

- ♦ In the case where relatively high concentrations of a parameter are measured and concentrations of all three fractions of the constituent are grouped closely, it is probable that most of the constituent is in the dissolved fraction. This conclusion can be drawn even though the actual elemental concentrations of the dissolved fraction are greater than the acid soluble fraction and/or the total fraction.

9. *Very little and inadequate discussion was provided on diurnal metal concentration variations. Considerable expansion of this subject is required. Nutrient data or MPDES discharge criteria from the Butte sewage treatment plant should be included and discussed. Additionally, the mechanism explaining nutrient consumption and the effects of Chlorophyll *a* on the ponds should be discussed in the test. Also, runoff conditions were suggested to cause variability in the April sampling episode. However, there is no discussion of what specific conditions may have caused these observed metal concentration variability. Finally, all other stations shown in Appendix A figures (i.e. SS-20, SS-26, and PS-12) exhibited diurnal variability of up to and over 100% for both copper and zinc total concentrations. Further explanation is required in the discussion to explain these phenomenon.*

Response: Nutrient data and MPDES discharge criteria from the Butte sewage treatment plant are not relevant to a data summary report for the Warm Springs Ponds Operable Unit.

Data collected during the Phase I RI (MultiTech, 1987) indicate precipitation-induced runoff causes temporal variations in metals concentrations in Silver Bow Creek. This mechanism was probably operative during the April diurnal sampling episode as measurable precipitation occurred in the Butte-Anaconda area prior to initiation of the sampling event.

The data summary report presents and summarizes data collected during the Phase II Remedial Investigation. As explained in the document, data were collected to fill data gaps identified for the site prior to completing analyses associated with the site public health and environmental assessment and feasibility study. Certain preliminary evaluations and general statements regarding data trends are presented in the report. Intensive and extensive analyses of hydrochemical mechanisms operating in the pond system and assessments of impacts to the area's hydrological environment were completed, as necessary, during preparation of the site public health and environmental assessment and feasibility study.





10. *It is stated on page 2-21 that metal concentrations decrease by 80 to 90% through the pond system. There is no discussion of the effects of residence time on these results. This needs to be addressed. Since the pond residence time at a minimum is at least several weeks, a mass-balance of a single day's sampling of such a system may result in misleading and inaccurate conclusions. Data collected during the Phase I RI should have been sufficient for this analysis.*

Response: The intent of the statement on page 2-21 was to indicate that measured metals concentrations at the outflows from the pond system at stations PS-11A and PS-12 were 80 to 90% less than those measured at the inflow to the pond system at station SS-19. We recognize that the removal efficiency of the pond system is best evaluated using a mass balance approach. This type of analysis was completed in conjunction with the Phase I Remedial Investigation (MultiTech, 1987, Appendix C).

11. *Diurnal variations in dissolved zinc concentrations at the inflow of the ponds (SS-19) are discussed on page 2-21. These variations are attributed to variations in pH (i.e. higher pH results in a lower dissolved fraction), and are supported by the September sampling when comparing Figure A2-1 with Figure A2-29 (Appendix A-2). However, further inspection of figures provided in Appendix A-2 indicates that during the July sampling an even larger variation in inflow pH resulted in little change in dissolved zinc concentrations (see Figures A2-1 and A2-32), even though the same minimum pH was attained. The reason for this needs to be investigated and discussed. Also, no mention is made of the extreme seasonal variation in copper and zinc concentrations. A discussion of the reasons for these variations needs to be provided.*

Response: The statement on page 2-21 concerning the diurnal variations in dissolved zinc concentrations is "These variations seem to be related to variations in pH." It is possible other factors are also important in affected dissolved metals loads within the system. Total zinc concentrations measured during the September and July sampling events are different. Sample temperatures were also different. Data collected during the Phase II RI should be sufficient to determine how the water quality changes diurnally and seasonally within the pond system and should provide some indication as to why these changes are happening.

On page 2-21 it states "Dissolved metals concentrations were higher in the winter at all sampling stations in the pond system." It is postulated that the lower pH that was measured during the winter sampling episode may have been at least partially responsible for the increase in dissolved metals concentrations.

12. *A vertical distribution of surface water samples at a few selected locations should have been conducted as part of the investigation. Vertical profiles should have been established ranging from the surface of the water down to the top of the sludge layer.*





*The information developed from these profiles would have allowed determination of the variability with depth of the various tested parameters. The data would also be useful from a quality assurance standpoint to determine how much variability in sample data is imposed by the sampling method used.*

Response: Samples were collected following the sampling and analysis plan (SAP) prepared for the Phase II RI at the Warm Springs Ponds. Data from these samples are sufficient to meet the objectives stated in the SAP. During the September sampling event, samples were obtained in Ponds 2 and 3 at two different sampling locations to determine if the areal variability in metals concentrations. The data from these samples were nearly identical and therefore one location was dropped. Because Pond 2 is very shallow (3 to 4 feet), it is unlikely that the vertical variability in metals concentration is significant.

It is not clear what quality assurance data would be generated by determining if changes at different depths were taking place. The sampling methods used were identical at a station throughout the sampling program. This RI was not developed to determine how different sampling methods may effect variability in the data. To try and avoid this variability, written standard operating procedures, adopted from industry standards and consistent with EPA guidance, were used on this project.

Further, samples collected from the inflow to and discharge from each pond within the system represent true composites, not just grab samples. The trends in analytical data generated from samples collected from pond inflow, within the ponds, and pond outflows indicate methodologies used to collect samples resulted in data sets which are representative of actual pond conditions.

13. *The difference between water quality "criteria" and water quality "standards" is not recognized in the RI. For example, the bottom of page 2-21 and Table 2-4 speaks of "aquatic standards", while Figures 2-5 to 2-20 refer to "ambient water quality criteria". The whole subject of Montana water quality regulations are not discussed within this report, resulting in a very superficial and inappropriate comparison of water quality to water quality standards. If CH2M Hill intends to compare water quality to State water quality standards, it must do so following appropriately designated water use classifications for Silver Bow Creek and Mill/Willow Bypass, and the water quality standards designated for these streams as detailed in Title 16, Chapter 20, Sub-chapter 6 of the Administrative Rules of Montana. Since Warm Springs Ponds is currently a MPDES discharge facility, **additional procedures for these facilities are contained in Sub-chapter 6.** Also, Warm Springs Ponds have no classification (ARM 16.20.604), because they are treatment ponds, and thus are not regulated. This means that it is inappropriate to compare water from within the pond system to water quality criteria, as is done in Table 2-4.*



Response: The intent of the remedial investigation report was to compare the data to water quality criteria. References to water quality standards in the document were made inadvertently. The data are amenable to comparison to a host of standards, criteria, etc. We chose to compare the data to water quality criteria as a means of characterizing the magnitude of concentrations measured in the area's surface water environment. It is not the purpose of the remedial investigation to establish the applicable or relevant and appropriate requirements (ARARs) for the site. These types of decisions will be made by appropriate regulatory agencies in conjunction with the site feasibility study and record of decision.

14. *Ambient water quality criteria are graphically represented in Figures 2-5 to 2-20, for copper and zinc, and are also referred to in Table 2-4. Numerical values for these criteria should be provided within the report. The reference given in Section 7.0 for these criteria is also incorrect; the most recent version of Quality Criteria for Water is Update No. 2, May 1, 1987. See also the comment above on the use of water quality criteria.*

Response: Please see our response to the comment above. Appropriate sections of Update No. 2 to the water quality criteria (May 1, 1987) were used to calculate exceedance criteria presented on Figures 2-5 through 2-20. This reference was inadvertently not included in Section 7.0. Numerical values for Figures 2-5 through 2-20 were determined using the following equations:

Copper (Chronic)

$$e^{(0.8545[\ln(\text{hardness})]-1.465)} = \mu\text{g/l}$$

Copper (Acute)

$$e^{(0.9422[\ln(\text{hardness})]-1.464)} = \mu\text{g/l}$$

Zinc (Chronic)

$$e^{(0.8473[\ln(\text{hardness})]+0.7614)} = \mu\text{g/l}$$

Zinc (Acute)

$$e^{(0.8473[\ln(\text{hardness})]+0.8604)} = \mu\text{g/l}$$

Hardness values are in mg/l as  $\text{CaCO}_3$





Average hardness concentrations used in the calculations are presented on Figures 2-5 through 2-20.

15. *Values for the zinc ambient water quality criterion (i.e. Gold Book) shown in Figures 2-13, 2-14, 2-15, 2-18, and 2-19 are incorrect and should be corrected. These figures all shown chronic AWC values below 100 ug/L. Based on a minimum hardness of 160 mg/l as CaCO<sub>3</sub>, the acute concentration criterion for zinc should be at least 157 ug/L (52 Federal Register 6213, May 2, 1987). As a result, Table 2-4 is also incorrect and should be revised to reflect the correct water quality criterion. This will alter the number of samples exceeding the water quality criteria. The table should also list the actual numerical values being used for water quality criteria.*

Response: Values for the zinc ambient water quality criteria illustrated on Figures 2-13, 2-14, 2-15, 2-18, and 2-19 are incorrect. The correct values for these criteria include the following:

HARDNESS (mg/l)	160	175	190	300
CHRONIC ZN CRITERIA (μg/l)	158	170	183	269
ACUTE ZN CRITERIA (μg/l)	174	188	202	297

Figures 2-13, 2-14, 2-15, 2-18, and 2-19 have been revised and are included as Attachment A to this response document.

Data and exceedance frequencies presented in Table 2-4 are correct. The chronic and acute zinc criteria formulas presented in the May 2, 1987 Federal Register Update No. 2 were used to prepare Table 2-4. Actual numerical values used in calculating zinc water quality criteria exceedances can be calculated using the formulas presented in response to Comment No. 14, above.

16. *Figures 2-21 and 2-22 illustrate arsenic and copper loading at several locations between the ponds and the upper Clark Fork during a relatively high flow event in May, 1986. Concentration and flow data should also be provided in the discussion because the quality of data appears inaccurate. For example, it appears in Figure 2-22 that Warm Springs Creek (SS-29) contributed 63% of the copper loading to the upper Clark Fork during this event. However, further examination of the data (contained in the supplemental Silver Bow Creek RI data summary) shows that for both Warm Springs Creek and Mill/Willow Bypass the acid soluble copper concentrations were considerably higher than total concentrations (0.137 vs. 0.085 mg/l and 0.074 vs. 0.057 ug/l, respectively). Thus, if total concentrations were used in the above analysis the loading contribution of Warm Springs Creek to the upper Clark Fork decreases to 39%, leaving*





*the source of an additional 35% of the total copper load in the upper Clark Fork unaccounted for. Since acid soluble concentrations should be lower than total concentrations by virtue of the digestion method, Figures 2-21 and 2-22 illustrates improper use of data, and should therefore be modified or deleted.*

Response: Concentration and flow data used to develop Figures 2-21 and 2-22 are contained in the supplemental Silver Bow Creek RI data summary report. We do not agree that the data presented in Figures 2-21 and 2-22 were used improperly. The fact that reported acid soluble concentrations were in some instances higher than total concentrations does not preclude use of the data. All data used to develop the two figures were validated. The use of total metals data to evaluate metals loading is also appropriate. The fact remains, however, that Warm Springs Creek was a significant source of metals loading to the Clark Fork River during the relatively high flow event sampled on May 31, 1986.

17. *The statement of fish kills on the upper Clark Fork (page 2-41) is not supported in any way by specific references, dates, locations, or data. An investigation of this magnitude should have researched and documented these events, along with specific climatological and hydrological data, so that a complete unbiased record is available for subsequent use in the FS. The report references fish tissue data from MDFWP, but this data was not presented. The statement that identifies Mill/Willow Bypass as the source of these fish kills was made without supporting data or references. Even though the report stated that MDFWP has not determined the source of the kills. The primary purpose of the RI is to collect and report data on the extent and magnitude of metals contamination and their effects on the environment, and not to perpetuate undocumented, second-hand information on events that cannot be supported by any data.*

Response: Specific references, dates, locations, and fish tissue analyses germane to five documented fishkills in the Upper Clark River and along the Mill-Willow Bypass are contained in Chapter 4 of the Warm Springs Ponds Feasibility Study (CH2M HILL, 1989).

18. *A concluding remark about the surface water investigation states that it is likely that planktonic algae, algae mats, and macrophytes all contribute to the reduction in concentration of metals in flows through the Warm Springs Ponds. However, a discussion of how these various factors influence metals removal was not included in the report. A more detailed discussion describing what was learned about the quantitative effects of metal removal by biological processes should be provided. Information on how much removal can be associated with biological processes versus physical and chemical processes should be provided.*



Response: A more detailed discussion on metals removal by planktonic algae, algae mats and macrophytes was presented in the Phase I RI report by Multitech (1987). It was not the objective of the Phase II RI to quantitatively determine the degree of metals removal by algae versus physical and chemical processes. The data that were collected are not suitable for that purpose.

19. *A great volume of data on inorganic parameters was generated in this investigation and in the treatability study which should have been utilized in the analysis and interpretation of results. Treatability studies in Section 2.4 demonstrate that sulfide, hydroxide, and carbonate equilibrium are all important factors to consider in assessing the ability of the pond system to remove metals. Equally important are parameters such as flow rate and temperature. A comprehensive investigation should tie all of these factors together and build correlations which will hopefully explain which processes dictate removal performance of contaminants in Warm Springs Ponds. This was not done.*

Response: The level of data analysis you suggest is better suited to the feasibility and remedial design stages of the CERCLA process. These types of evaluations will be made, as necessary, during subsequent phases of the Warm Springs Ponds feasibility study and remedial design/remedial action (RD/RA).





## APPENDIX A-3, TREATABILITY STUDY AND DATA SUMMARY REPORT WITH ATTACHMENTS

### 1.0 INTRODUCTION

#### 1.1 PURPOSE AND SCOPE OF WORK

1. *In general, the results gained from treatability tests in this section are useful for selection and design of treatment alternatives. As expected, the results from lime addition showed the removal of metals from Silver Bow Creek can be enhanced by increasing pH and settling times. Dissolved metals were effectively reduced by increasing pH with lime, while total metals tended to decrease with increasing settling time. The addition of sulfide together with lime also resulted in improved removal performance as expected. Metal sulfides offer lower solubilities than do the corresponding metal hydroxides.*

Response: No response necessary.

2. *The tests do not, however, take into account the important factors and variability that biological processes impose on the Warm Springs Ponds system. The tests also do not simulate the flow velocities that are present in the pond system. These two factors combined play an important role in treatment performance. However, these conditions would be difficult if not impossible to simulate in the laboratory. In order to incorporate these factors, an on-site pilot test would be required.*

Response: We agree with this comment. On-site pilot testing may be appropriate during remedial design.

3. *Settling aids were not tested in the treatability study, although this would have been an ideal opportunity to do so. Addition of a flocculent after lime and/or sulfide treatment may greatly increase settling times and increase efficiency for metals.*

Response: Testing of such additives could accompany pilot testing during remedial design.

#### 1.2 SITE DESCRIPTION AND CONTAMINANT HISTORY

No Comments

#### 1.3 METALS REMOVAL CHARACTERIZATION

1. *It is stated on page 1-4 that ice buildup in the winter may cause short-circuiting of flows and reduced hydraulic detention time. However, no data are provided in the RI or*





*treatability study to suggest that flows are short circuiting in the pond system due to ice buildup in the winter. This matter should have been resolved in the treatability study by conducting an onsite test during winter activities. One test that should have been conducted involves use of a chemical tracer injected at the inlet of the pond system. The effluent from the east and west decant towers should then have been monitored daily for evidence of the tracer.*

Response: You are correct in stating that no data regarding surface water travel times were collected during the Phase II RI. Estimates of travel time were presented in the Phase I RI (MultiTech, 1987, Appendix C). It is our understanding that ARCO is also collecting data to evaluate this issue and that these data have been or will be submitted to the agencies for inclusion in the administrative record. We concur that these data may be necessary depending upon the remedial alternative selected for the site. Such data will be collected, if necessary, in support of remedial design for the site.

2. *The same paragraph also mentions that increased flow velocity will cause resuspension of pond bottom sediments and cause flow of sediments from the ponds. A quantitative value in support of this should be included in this statement. The pond system can handle a range of flows and only significantly high flow velocities should result in resuspension of pond bottom sediments.*

Response: We were unable to validate gradation data for pond bottom sediment samples collected at the site. These data were to be utilized to evaluate the probability of resuspension of pond bottom materials relative to increased flow velocities in the pond system. Such data are reportedly being collected by ARCO at the Warm Springs Ponds and should be submitted to the agencies for inclusion into the administrative record. We concur that such data are necessary to evaluate sediment resuspension and samples for this purpose will be collected in support of remedial design.

## 2.0 METHODS

### 2.1 SAMPLE COLLECTION

1. *In Section 2.1.2, "Runoff" Sample, a statement should be made in the study to indicate what kind of runoff condition is being simulated and how representative the sample is to actual runoff into the pond system. The runoff sample used in this study assumes an extremely large increase in suspended and dissolved metals (see Table 3-1) which may or may not be the case during high flow runoff conditions. If anything, this sample would most likely represent worst case conditions for metal loading and this should be stated in the study.*



Response: The condition being simulated is surface runoff across saturated soil that contain significant concentrations of selected metals in a localized area. The runoff sample may be considered indicative of "first water" after a dry period, from metal-bearing surface materials. The actual concentrations in Silver Bow Creek will vary depending on a number of factors. These include the length of time since the last precipitation event and the specific locations where precipitation occurs (i.e. the percentage of precipitation on tailings vs. non-tailings areas).

## 2.2 TESTING PROCEDURES

1. *The testing procedure used is generally simple and straight forward. Experiments were carried out in batches by adding predetermined amounts of precipitant to water samples. The samples were stirred and allowed to settle. The test procedures used are typical of those used in laboratory scale testing. The type of lime used and the method of application (e.g. slurry or dry powder) should be identified in the test procedure. Also, the stirring time should be recorded. These factors can have a significant effect on test results. The same holds true for the addition of sodium sulfide.*

Response: ACS-grade hydrated lime from the laboratory supply was added to the samples as a dry powder. Small doses were added incrementally in order to achieve the target pH. Stirring times varied, depending upon the target pH. Effects of mixing and the method of reagent addition should be reevaluated during pilot testing associated with remedial design.

2. *The value of running tests at the high pH range (11 and 11.5) is questionable. Attaining such high pH levels in the pond system may be impractical, as enormous amounts of lime would be required. Also, an acid addition step would be required to lower pH levels back down below 9.5 before discharge.*

Response: The value in testing lime treatment at up to pH 11 lies in the improved removals of several important metals from the ponds notably arsenic, copper, and zinc. It is also noteworthy that the pH usually fell to below 9.0 after 5 to 20 days following lime treatment. The cause is attributed to absorption of atmospheric carbon dioxide. We agree that it seems prudent to include provisions for pH reduction following lime treatment, whenever carbon dioxide absorption is inadequate.

3. *In addition to metals, cations and anions were analyzed in samples. However, the study fails to utilize most of the cation and anion data to support or supplement results for metals removal. A discussion of this data should be provided.*





Response: The removal of transition metals whose toxicity affects aquatic organisms is the focal point of the report. Discussion of supplemental water quality data would neither affect the conclusions of the report nor materially contribute to an understanding of the treatment effectiveness. No discussion is necessary.

## 2.3 ANALYTICAL

No Comments.

## 3.0 RESULTS AND DISCUSSION

1. *The test results indicate that dissolved metals were reduced and settled by addition of lime. As pH was increased, the dissolved fraction of metals decreased and thus removal efficiency was enhanced. In general, the concentration of dissolved metals stabilized after about 4 hours of reaction with lime. Precipitated metals continued to settle throughout the 20 days of the test. Longer retention times provided better removal performance. The majority of metals that remained in water samples after settling appeared to have been dissolved.*

Response: With the exception of zinc, dissolved and total metals concentrations were indistinguishable after about 15 days. At pH 11, dissolved and total zinc concentrations were similarly indistinguishable.

2. *As expected, the addition of sodium sulfide lowered the dissolved fraction of metals and increased the rate of reaction. Metal sulfides have lower solubilities than the corresponding metal hydroxide. Raising the amount of sulfide added did not appear to increase removal performance.*

Response: Proper control of sulfide dosage can be difficult since under- and overdosing can increase soluble concentrations of some metals, and sulfide may be oxidized at low concentration under aerobic conditions.

3. *The concentration of dissolved and total metals in the "Winter" sample are fairly representative of what is normally observed in Silver Bow Creek. The "Runoff" sample used in this study was supposed to represent an actual high flow runoff event. However, as discussed earlier, it more likely represents a worst case condition. Water samples from the creek were stored for more than 100 days before testing. The reason for this long storage period should be stated. The long storage time did not appear to appreciably affect the concentration and distribution of metal contaminants.*



Response: See response to Section 2.1, comment No. 1, concerning the representativeness of the runoff sample. The runoff sample was stored for approximately 90 days prior to the start of testing. The winter sample was stored for approximately 20 days before starting the lab scale test program. The runoff sample was stored for this long period because of MDHES activity scheduling (primarily funding) constraints. The sample time could not be delayed because it would have been difficult if not impossible to collect this sample after the tailings areas were either frozen or snow covered.

It was anticipated that the water would need to be stored for this period of time prior to testing and every precaution was made to store the samples such that it would have a minimal effect on the test results (e.g. the water was refrigerated prior to use). Additionally, the samples were fully analyzed upon initial collection and just prior to testing to evaluate any potential changes. As indicated by the commentor, the storage time did not appear to appreciably affect the concentration and distribution of the metal contaminants.

The barrel scale testing was initiated after the completion of the lab scale testing. Hence, the water samples were stored for a longer period of time prior to these tests as compared to the start of the lab scale test program.

4. *Dissolved cadmium is higher than total cadmium in some test results. An explanation of why this is so should be provided.*

Response: Statistical variability in aliquot extractions (especially for metal precipitates) and chemical analyses at low metal concentrations are responsible for these anomalies. The user of the data is advised to apply discretion when interpreting these results. Also, see response to comment No. 8, Section 2.3.

### 3.1 LAB-SCALE, "WINTER" SAMPLE, LIME TESTS

1. *Lime tests show that most of the removal occurred within 2 days after lime was added to the sample. During the course of the tests with lime, the pH shifted uncontrollably. Samples starting at pH 8.0 shifted to 8.6 while samples starting at pH 9, 10 and 11 shifted to pH 8.5 by the end of the test (see Table 3-2). This uncontrolled pH shift to a common point of 8.5 is probably due to natural carbonate equilibrium with the atmosphere. The shift in pH has a measurable effect on treatability test results, which is especially apparent in tests using "runoff" samples (Section 3.5). For example, Table 3-7 shows dissolved lime concentrations increasing dramatically as a result of pH shifting from 9 to 7.9. In addition, a review of the data in attachment A3-1 for the sample which had no lime addition shows that pH increased from 7.5 to 8.5 during the course of 20 days. A more detailed discussion of this shift in pH and its effect on treatability should be provided.*





Response: We agree with the interpretation presented in this comment that the uncontrolled pH shift that was observed in the treatability tests was probably due to natural carbonate equilibrium with carbon dioxide in the atmosphere. The comment also refers to providing additional discussion regarding the dissolved "lime" concentrations in Table 3-7. We assume that the commentor meant "zinc" rather than "lime." Additional discussions on the variation of the dissolved zinc concentration as a function of time are presented in Section 3.4.4. We agree that the increase in dissolved zinc concentrations for the pH 9 test was a result of the shift in pH to 7.9 as a probable result of the system approaching equilibrium with atmospheric carbon dioxide.

2. *The uncontrolled change in pH appears to be buffered somewhat by addition of sulfide (Table 3-3), where an initial pH of 9.0 stabilized at 8.9 after 20 days. Also, sulfide tests run at low temperature resisted changes in pH (Table 3-6). This is expected since carbonate equilibrium is slowed at lower temperatures.*

Response: No response required.

3. *The same effects of carbonate equilibrium described above are undoubtedly occurring within the pond system. However, the effect is buffered somewhat by low temperature in the winter and by natural biological processes during warmer seasons. These are all important points to bring out. However, the treatability study fails to make any mention of them. A discussion of these effects should be included as part of the treatability study.*

Response: Natural biological processes were ignored because they could not be adequately simulated in the laboratory, as stated in the introduction of the report. Other controllable parameters, including temperature, were varied under controlled laboratory conditions, and the effect on metal removal, the primary criterion, were duly reported.

### 3.2 LAB-SCALE, "WINTER" SAMPLE, LIME PLUS SULFIDE TESTS

1. *Adding sulfide gave measurable increases in removal performance over lime alone at pH 9. Sulfide addition also seemed to speed reaction rates. Increasing sulfide amounts above 0.08 mg/l did not appear to increase removal of metals. Addition of 0.08 mg/l sodium sulfide is equivalent to adding only about 33 lbs/day to Silver Bow Creek at a flow of 75 cfs. Tests conducted on a larger scale (Section 3.6) seem to indicate a decrease in removal efficiency. However, dissolved metals were reduced to approximately the same levels in larger scale tests (Table 3-8). For water quality purposes, sulfide concentrations should have been measured in the effluent samples but were not.*





Response: The primary criterion is metals removal. Sulfide residual measurements remain to be made during pilot testing associated with remedial design, if sulfide usage is a part of the process. The dissolved oxygen measurements reported in Appendix A provide indirect evidence that little, if any residual sulfide should remain. Sulfide measurements at such low residual sulfide concentrations would be difficult, if possible.

2. *In laboratory test conducted on "Winter" samples using sulfide addition, the initial target pH of 9 and 11 was exceeded (See Tables 3-3 and 3-4). The same problem occurred in low temperature tests (Table 3-5 and 3-6). Varying the starting pH influences test results and makes it difficult to compare data. An explanation should be provided as to why target pH levels were exceeded in these tests (over addition of lime, sulfide addition, tighter controls, etc.). An explanation should also be given as to why less lime was required to bring a "Winter" sample to pH 9.3 in tests using sulfide (0.0178 mg/l), than was required to bring the same sample to pH 9.0 in tests using lime (0.019 mg/l).*

Response: It is unknown why pH targets were exceeded during the laboratory tests. The tests did indicate that metals were still effectively removed under these conditions, illustrating the "forgiving" nature of lime treatment. The difference in lime dosage for sulfide-treated versus sulfide-free water is considered inconsequential (<7%) considering inherent variability in pH measurement, lime addition by repeated small doses, and the volumetric measurement associated with withdrawing a liquid sample for treatment. Confirmatory pilot testing during the remedial design phase is assumed to be necessary to address any questions that remain after these laboratory simulations.

### 3.3 LAB-SCALE, "WINTER" SAMPLE, LOW TEMPERATURE LIME TESTS

No Comments.

### 3.4 LAB-SCALE, "WINTER" SAMPLE, LOW TEMPERATURE LIME PLUS SULFIDE TESTS

No Comments.

### 3.5 LAB-SCALE, "RUNOFF" SAMPLE, LIME TESTS

No Comments.

### 3.6 BARREL-SCALE, "WINTER" SAMPLE, LIME TESTS

No Comments.



### 3.7 BARREL-SCALE, "RUNOFF" SAMPLE, LIME TESTS

No Comments.

### 3.8 TOTAL SOLIDS PRODUCTION, "WINTER" AND "RUNOFF" SAMPLES, LAB SCALE LIME TESTS

1. *A detailed discussion should be included in this section regarding the significance of various findings. This should also include a discussion on results on the EP Toxicity. A statement should be made regarding how the production of solids will affect selection of a final treatment alternative. The study should have evaluated how much of the solids produced were due to undissolved lime and undissolved sodium sulfide. The characteristics of solids produced in this study should have been compared with the results of the Pond Bottom Sediment Investigation in Section 4.0.*

Response: The intent of the "Treatability Study and Data Summary Report . . ." was to report and summarize data, rather than to provide an extensive discussion of the significance of the data. Any interpretation, comparison or analysis that might be warranted will be provided in the feasibility study. In addition, the type of interpretative discussion suggested in the comment does not appear justified considering the nature of the tests.

It is expected that there would be significant differences between the treatability sludges and the pond bottom sediments. A component of the pond bottom sediments originated as suspended solids from Silver Bow Creek under a wide variety of flow conditions. Additionally, the composition of the pond bottom sediments is affected by the biological activity in the ponds. The sludges produced in the treatability tests represent only the results of chemical treatment with little influence from suspended solids in Silver Bow Creek.

## 4.0 QUALITY ASSURANCE/QUALITY CONTROL

No Comments

## 5.0 CONCLUSIONS

1. *One of the stated objectives of the treatability study was to determine if precipitation and settling technology utilized in the pond system can meet Gold Book Criteria. This was not discussed in the concluding remarks. The results indicate that adding lime to a sample taken from Silver Bow Creek in the winter, raising the pH to 11, and allowing approximately 20 days of settling will result in levels of Cu, Zn, As, and Cd which meet Gold Book Criteria. The data are insufficient to make a determination for lead,*





*although, it appears that lead also will meet criteria at pH 11. However, as mentioned earlier, it may not be possible to run the pond system at pH 11. At pH 9 and 0.08 mg/l sodium sulfide, the results show that Gold Book Criteria can be met for the metal elements of concern except for copper which levels off at around 30-50 mg/l. Essentially all of the remaining copper is in the dissolved form. It should also be stated that the results in this study are based on chemical precipitation only and that the biological processes which exist naturally in the pond system were not included as part of the treatability study to assist in metals removal, including copper.*

Response: Operation of the pond system at pH 11 is not precluded by virtue of the test results nor any of the comments offered above. Questions and technical issues that remained unanswered after the foregoing tests may be addressed during pilot testing associated with remedial design.



### 3.0 GROUND-WATER INVESTIGATIONS

#### COMMENTS

#### 3.1 METHODS

##### 3.1.1 Electromagnetic Survey

1. *The description of the electromagnetic (EM) survey method used is incomplete. There is no literature cited for the particular method used, or a description of applicable data analysis procedures, or specific limitations, such as depth of search. This type of information is also absent from the field operations plan (FOP), and EM survey procedures are not detailed in the quality assurance project plan (QAPP). As stated in the QAPP, page 1, EPA policy requires all RI/FS activities to be under the control of a centrally managed QA program. This requirement applies to all environmental monitoring and measurement efforts mandated or supported by the EPA.*

*Since there are no documented assurance parameters that define the acceptable quality of the EM data, the data have limited value and are useful only as an indicator of the general conductivity of the terrain traversed. In particular, there is no background data presented to support the contention that the presence of shallow ground-water conditions serves to factor out variations in lithology. It is inconceivable that terrain covered by relatively extensive metallic tailings deposits would not generate high EM data, especially since EM prospecting methods were developed particularly for locating ore bodies.*

Response: The method used to complete the EM survey was presented in NETSOP-30 of the project field operations plan (Document No. WSTP-FOP-F-R0-090387). All EM data were collected in accordance with specifications presented in the operators manual (Geonics Limited, 1984). As stated in the text, it was our intention to use the EM survey data only as an indicator of "relative" earth-conductivity anomalies in the vicinity of the Warm Springs Ponds. For this reason, complex and intensive survey methods were not used and exhaustive data analysis was not completed.

When operated in accordance with the manufacturer's recommendations, the EM31-D is designed to directly measure the electrical conductivity of subsurface material (including groundwater if present) to depths of approximately 20 feet. Therefore, anomalously high conductivity zones identified with the EM31-D may be attributable to lithologies containing metallic materials, high conductivity groundwater, or variations in subsurface lithologies. As stated in the Phase II RI report, the purpose of completing an EM survey at the Warm Springs Ponds was to provide data to assist in siting monitoring wells. A secondary purpose of collecting these data were to use the information to aide in identifying the lateral extent of degraded groundwater as determined by relatively high conductivity values. It was not our intention to use the





EM data as direct evidence of degraded groundwater. The quality of water both within and outside of high conductivity zones identified with the EM31-D was determined through subsequent monitoring well installation and sampling.

We agree that relatively high electrical conductance measured in certain areas may be attributable to the presence of buried tailings. Therefore, the EM survey data is likely to prove useful in evaluating certain remedial alternatives at the Warm Springs Ponds during the site feasibility study and for remedial design.

2. *The test states that several EM transects were completed upgradient of the pond system for comparative purposes. These transects are not specifically identified in Figures 3-1, 3-2, and 3-3, or compared with any other transect data presented. The report should be revised to include identification and interpretation of the upgradient EM data as compared to downgradient EM data and ground-water quality data.*

Response: Transect A was completed upgradient (south) of Pond 3 and is shown on Figure 3-1 in the Phase II RI report. Transect P was completed approximately one mile upstream of Pond 3 near the Stewart Street Bridge. Transects F, J, and M were completed downstream from the Warm Springs Ponds at Perkins Lane Bridge, Galen Bridge, and approximately 1/4 mile downstream of Warm Springs Road, respectively. Locations of Transects F, J, and M are shown on Attachment B to this response document. These transects were not shown on Figures 3-1 through 3-3 because of the limited coverage of the maps used for the report. Field notes for transects F, J, M, and P are contained in Appendix B-1 of the Phase II RI report.

Our review of EM survey data for Transect A indicates that, in general, all electrical conductivity values collected at Transect A were less than 100 millimhos/meter with the exception of those stations situated on what was determined in the field to be Tertiary deposits. The relatively higher electrical conductivity measurements recorded on Tertiary sediments are likely a result of the finer grained nature of those sediments relative to coarser grained sediments typical of Silver Bow Creek alluvial material.

EM data collected at Transect P near the Stewart Street Bridge were all less than 100 millimhos/meter with the exception of those sites situated directly on exposed tailings. It is evident from review of field notes for Transect P that exposed tailings deposits do result in higher electrical conductivity values. Electromagnetic data collected at Transect J near the Galen Bridge were all relatively low (less than 75 millimhos/meter) with the exception of those values measured on Tertiary sediments distal to the Clark Fork River.

Discussions presented in the Phase II RI report and review of Figure 3-2 and 3-3 suggest that in general, electrical conductivity values greater than about 100





millimhos/meter may indicate areas of anomalously high earth conductance values. These relatively high values may be the result of the presence of elevated conductivity groundwater or buried or exposed tailings.

3. *All of the EM transects completed during the Phase II RI are not identified in any of the figures presented in the report. The EM survey field notes in Appendix B-1 indicate that transects F, J, M, and P were completed in addition to the transects identified in Figure 3-1. The report should be revised to include their locations and an interpretation of the EM survey results as compared to the other transect results, or a detailed explanation of why these particular sets of transect data were not discussed in this report.*

Response: Transects F, J, M, and P are discussed in response to Comment No. 2, above.

4. *The complete location of transect O is not identified on Figure 3-1. EM survey field notes included on pages 29-31 in Appendix B-1 indicate that transect O also included 22 additional stations in an east-west line between the Mill-Willow Bypass and the Opportunity tailings ponds (stations O31 - O52). Furthermore, presentation/interpretation of EM survey results for transects A, O and the segment of transect N that was completed within the western portion of Pond 1 are not included in the test. The report should include such information or a detailed explanation of why the information was not included in this report.*

Response: The western portion of transect O was not shown on Figure 3-1 because it was not within the borders of the Warm Springs Ponds Operable Unit. The western portion of Transect O was generally a straight line extension due west from that portion of transect O shown on Figure 3-1. Our review of field notes (Appendix B-1) indicates that relatively high EC values were measured west of Interstate 90. These high values may suggest high conductivity groundwater has migrated toward the Warm Springs Ponds from the Opportunity Ponds area.

EM data for transect A was discussed in response to Comment No. 2, above. Our review of EC data for transect N indicates the western portion of Pond 1 exhibits highly variable conductivity values ranging from 53 millimhos/meter to 121 millimhos/meter with no distinct trend. The variability of EC data in this portion of Pond 1 is likely due to the presence of exposed and buried tailings within the Pond 1.



#### 3.1.1.1 Changes to the Project Work Plan

1. *A specific work plan document is not cited in this section of Section 7.0 References Cited. The report should be revised to cite which document includes the Warm Springs Ponds Phase II RI work plan.*

Response: The scope of work for the Warm Springs Ponds Phase II Remedial Investigation was included in the draft Silver Bow Creek Selected Data Gaps Study Plan referenced in Section 7.0 under CH2M HILL (1987a).

#### 3.1.1.2 Presentation of Data/Results

1. *Figures 3-2 and 3-3 illustrate an interpretation of the results of the EM surveys for the area below Pond 1 and the Mill-Willow Bypass. Neither of these figures include ranges of values for the following transects:*
  - o Upgradient transects (these are not clearly identified in the test or field notes)*
  - o Transects F, J, M, and P (locations not identified in Figure 3-1)*
  - o Transects A and O (location incomplete in Figure 3-1)*
  - o Transect N (data missing for the segment completed along the northwest side of Pond 1)*

*An explanation of why an interpretation of data for these transects was not included in the report needs to be provided. The report should be revised to either provide such an explanation or present and interpret all the EM data and results.*

Response: EM transects completed both south and north of the Warm Springs Ponds were not shown on Figures 3-1 through 3-3 because the coverage of the maps used in presenting RI data did not extend to these areas. Downgradient transects F, J, and M are shown in Attachment B of this response document.

The complete length of transect A is shown on Figure 3-1. The western portion of transect O extends due west from transect O shown on Figure 3-1 to the base of the Opportunity Ponds berm.

Survey locations for that portion of transect N completed within Pond 1 are shown on Figure 3-2. EC values recorded at these stations are contained in the field notes contained in Appendix 3-1.





Data resulting from every EM survey transect were not specifically discussed in the data summary document because there was no apparent need to complete such analyses. The EM survey was intended to identify areas of degraded groundwater and help site monitoring wells at the Warm Springs Ponds Operable Unit. Based on results of the groundwater investigation at the Warm Springs Ponds, we believe that the EM survey data did provide useful information for siting monitoring wells.

2. *The field notes provide incomplete and very generalized descriptions of transect alignments and individual EM survey stations. Consequently, it is very difficult for anyone reviewing the EM survey maps and field notes to match the field conductivity data with the transects identified on Figures 3-2 and 3-3. For example, the alignment of stations along transect G is difficult to distinguish on Figure 3-2 and does not appear to correspond with that shown on Figure 3-1. This discrepancy cannot be resolved by referring to the field notes because the very generalized descriptions (illegible in some cases) of station locations provide inadequate information to match the data with stations show on Figure 3-2. As such, it is not possible for any reviewer to determine if the ranges of EM survey values presented in Figures 3-2 and 3-3 accurately reflect the field data. The report should be revised to at least include an indication of a few key station numbers on each transect presented in Figures 3-1 and 3-2 and to correct the inconsistencies between these figures.*

Response: Locations and site numbers for certain key EM stations are contained on a site map contained in Attachment C to this response document.

3. *There is a discrepancy between the results indicated in Figure 3-3 and those in Figure 3-1 and the field notes. Figure 3-3 includes a range of EM conductivity on the west side of Mill-Willow Bypass west of Ponds 1 and 2 while Figure 3-1 and the field notes indicate that an EM transect was completed only on the east side of the bypass west of Ponds 1 and 2. The report should be revised to correct this discrepancy.*

Response: You are correct, EM data were not collected west of the Mill-Willow Bypass adjacent to Ponds 1 and 2. Extrapolation of the blue shaded portion in the area adjacent to Ponds 1 and 2 and west of the Mill-Willow Bypass (Figure 3-3) is using the data beyond its limits.

4. *The EM survey field notes in Appendix B-1 include amplitude data for both the horizontal and vertical vector components (space components) of the magnetic field relative to the source. A comparison of the range of conductivity values illustrated in Figure 3-2 with the field notes indicates that the horizontal component of measured electrical conductivity was used to determine conductivity ranges. This is not noted in Figures 3-2 and 3-3. Furthermore, the test does not explain why the horizontal component of terrain conductivity was used, as opposed to either the vertical component*



*or the total field (sum of horizontal and vertical vectors). The significance of selecting the horizontal component should be explained. As stated above, the report should include a technical description of the EM survey method used and applicable data analysis procedures as found in technical literature, particularly since there are no applicable EPA standards or guidelines for collecting and interpreting EM survey data.*

Response: The horizontal component of electrical conductivity values was used to develop Figures 3-2 and 3-3. We used the horizontal component data to simplify data presentation. Assuming that the electrical conductivity of the subsurface is laterally continuous, rotation of the instrument in a horizontal plane about the transmitter should produce the same relative readings (Geonics, 1984). In general, readings obtained at a 90 degree angle about the horizontal plane were consistent with few exceptions. Initial interpretation of the EM data indicated that using the sum or average of the two horizontal readings would not significantly change the overall results of the EM survey.

Rotating the EM31-D 90 degrees about its longitudinal axis (vertical vector component) essentially reduces the effective depth of penetration of the instrument in half (Geonics, 1984). Because the purpose of the EM survey was to identify anomalously high electrical conductivity areas in order to site monitoring wells, analysis of the data using the horizontal or vertical component does not matter, as long as a consistent orientation is used.

The manufacturer suggests it is more informative to evaluate spatial variations of terrain conductivity rather than to evaluate absolute values of the conductivity itself (Geonics, 1984). In other words, the instrument is an effective tool for identifying anomalies in the electrical conductance of the subsurface. EM survey data plotted on Figure 3-2 do show distinct areas which exhibit relatively high electrical conductivity.

5. *The EM survey results appear to indicate three distinct areas of shallow terrain exhibiting relatively high field conductivity downstream of Pond 1 (Figure 3-2). A comparison of EM data with the measured specific conductance of groundwater sampled from the monitoring wells should have been made. This would have allowed a more meaningful evaluation of the measured specific conductance of shallow groundwater.*

Response: Although specific electrical conductivity data for groundwater samples obtained in the area downgradient of Pond 1 were not plotted and presented as a figure in the Phase II RI report, manganese and sulfate data were presented. Manganese and sulfate concentrations measured in wells completed in the shallow sand and gravel aquifer downgradient of Pond 1 (Figures 3-10 and 3-11, Phase II RI report) correlate well with EM survey data. Our review of Figures 3-10 and 3-11 indicates that manganese and sulfate concentrations measured in monitoring wells





completed immediately below the Pond 1 berm (WSP-GW-02, -03, -13, and -19) were relatively higher than concentrations for those parameters measured in other monitoring wells. These wells are all located within the EC contour lines of 125 millimhos/meter or higher as depicted on Figure 3-3.

The data are available to evaluate relationships between EM values and specific conductivity in groundwater below the Pond 1 berm. These analyses will be completed, if necessary, in support of the site feasibility study and the site public health and environmental assessment.

6. *Although there is a very limited number of monitoring wells along the Mill-Willow Bypass, the EM survey data does not appear to reasonably reflect the measured specific conductance of groundwater sampled from wells along the east side of the bypass. However, there are no monitoring wells along the west side of the bypass to substantiate the conclusion that areas of apparent high conductivity upstream of Pond 3 are attributable to the Opportunity tailings ponds. Alternately, the higher ranges of conductivity values along the bypass upstream of Pond 3 may be associated with the relative abundance of ore tailings deposits that exists along the upper half of the channel, as described at the top of page 5-11.*

Response: We agree, the high EC values measured upgradient of Pond 3 may be attributable to the abundance of both exposed and buried tailing deposits in this area.

### 3.1.2 Monitoring Well Construction

1. *Lithologic descriptions of the various strata encountered during well construction could have been further substantiated with gradation analyses performed on samples of the various units. However, no gradation analyses were performed to verify field descriptions of coarse- and fine-grained materials included in the Well Completion Logs (Appendix B-2).*

Response: Gradation analyses of material samples collected and logged during monitoring well installation were not completed during the Phase II Remedial Investigation because these data were not necessary to fulfill project objectives. In addition, these types of data were not identified as a data gap to complete a site public health and environmental assessment or the site feasibility study. Experienced hydrogeologists completed borehole logging and performed visual classifications of grain sizes encountered in the various lithologies encountered in accordance with their geological training. The term "coarse-grained" was used to describe any material that was larger than silt. "Fine-grained" included material that was determined to be silt-sized and smaller.





2. *There are no well completion logs included for the test well and observation wells constructed for the performance of aquifer tests. Well construction information is required for the proper review and independent analysis of aquifer test results.*

Response: Well logs for pumping well WSP-PW-01 and nearby observation wells were inadvertently omitted from Appendix B-2. These logs are included in Attachment D to this response document.

### 3.1.3 Ground-water Sampling

#### 3.1.3.1 Changes to the Original Work Plan

No Comments.

#### 3.1.3.2 Presentation of Data/Results

1. *The complete set of ground-water quality analyses for the May, 1988 sampling period is missing from the copy of Appendix B-4 that was reviewed. This information needs to be incorporated in the report.*

Response: A complete May, 1988 groundwater quality data base is included as Attachment E to this response document.

2. *Although ground-water contamination involving some secondary constituents, particularly iron, manganese and sulfate, is considered to be relatively widespread, the investigator correctly recognizes that the physical area where primary MCL's are exceeded for arsenic and cadmium is limited to Pond 1 and a relatively small area below the northeast quadrant of Pond 1.*

Response: No response necessary.

### 3.1.4 Ground-water Level Monitoring

1. *The FOP does not include a standard operating procedure for the two staff gages installed in the Mill-Willow Bypass. Consequently, there are no documented assurance parameters that define the acceptable quality of the staff gage data. Furthermore, there is no documentation that indicates staff gage installation, monitoring and measurement efforts were under the control of the RI QA/QC program.*



Response: A standard operating procedure for installing staff gages in the Mill-Willow Bypass was not included in the project field operations plan. The procedure used to construct, install, and monitor staff gages located in the Mill-Willow Bypass included the following:

- ♦ The staff gage was constructed by attaching a 3.3 foot factory-produced porcelain-plated staff gage on a pressure-treated 2-inch by 6-inch board. Two galvanized steel rods were inserted into the stream bottom at a location characterized by relatively low stream energy. The rods were advanced to a minimum depth of three feet into the channel. The staff gage setup was attached between the installed rods using six stainless steel lag bolts. This method of staff gage installation is commonly used by the U.S. Geological Survey.
- ♦ The elevation of the zero line on the staff gage was determined in conjunction with the level survey performed to identify measuring point elevations at monitoring wells in the area. This was completed by determining the elevation of the top of the staff gage and subtracting the height from the surveyed point to the zero line.
- ♦ Field personnel completed staff gage measurements by observing the stream level with respect to depth increments displayed on the staff gage. Personnel made staff gage readings twice during each monitoring episode to insure measurements were repeatable.

#### 3.1.4.1 Changes to the Project Work Plan

No Comments.

#### 3.1.4.2 Presentation of Data/Results

1. *Static water level data for December, 1987 and January, 1988 are not included in Appendix B-5. These data are included as a part of the ground-water quality data base presented in Appendix B-4.*

Response: Static water level data measured in December, 1987 and January, 1988 were not presented in Appendix B-5 because all monitoring wells planned for this investigation had not yet been installed. The static water level data presented in Appendix B-5 is complete for a twelve month period.

2. *There is a discrepancy between the static water level elevations in Figure 3-22 and the May, 1988 data in Appendix B-5 for the following wells:*





<u>Well No.</u>	<u>Figure 3-22</u>	<u>Appendix B-5</u>
GW-07S	4854.2	4857.4
GW-08S	4868.0	4868.6
GW-10S	4805.6	4806.2
GW-12S	4792.8	4792.5
GW-16S	4799.8	4797.1

Response: You are correct. Groundwater elevations shown on Figure 3-22 were apparently incorrectly plotted. Review of Figure 3-22 indicates these water level discrepancies would have little effect on the overall configuration of the water table map shown on Figure 3-22. The largest discrepancies noted were for wells GW-07S and GW-16S (-2.8 and + 2.7 feet, respectively). These differences would result in a shift of the 4855 foot contour line slightly to the north near well GS-07S and the 4800 foot contour line would shift slightly to the south near GS-16S.

3. *Water table elevation contours are inferred between the Mill-Willow Bypass and the Opportunity tailings ponds (not labeled on Figure 3-22). At the top of page 3-39, it is stated that these inferred water table contours are based on 1985 data developed at the Anaconda Smelter NPL site. Since both the Phase I and Phase II RI reports suggest that the quality of the Mill-Willow Bypass is affected to some degree by ground-water flow from the Opportunity Ponds area, water levels in the monitoring wells downstream of the Opportunity Ponds during the WSP RI should have been measured. Such data are needed to develop a complete characterization of ground-water movement and discharge to the Mill-Willow Bypass from the southwest and from the east.*

Response: Water quality samples were not collected from monitoring wells downgradient of the Opportunity Ponds because these wells were outside of the Warm Springs Ponds Operable Unit. This investigation focused on the Warm Springs Ponds. ARCO is completing RI/FS activities at the Opportunity Ponds. Concurrent data collection from the two sites may be necessary to insure remedial activities at the sites are compatible. The need for such data collection will be evaluated and completed, if necessary, prior to remedial design development for either of the two sites.

4. *The discussion pertaining to vertical ground-water gradients suggests that upward gradients along the Mill-Willow Bypass and the area below Pond 1 reflect a hydraulic association with the ponds. Although this is likely true to some degree, the comparison of the water levels in upgradient wells GW-01, GW-06S and GW-06D in the southern portion of the OU also indicates an area of ground-water discharge. Thus, areas of ground-water discharge are not uniquely associated with the ponds in relation to ground-*



water conditions along the Silver Bow Creek/Clark Fork drainage in the Deer Lodge Valley. Work by Konizeski and others (1968) indicates these streams on a regional scale serve as receptors of ground-water discharge over their entire length in the Deer Lodge Valley. The RI ground-water level data confirm that this is true within the OU.

Response: We agree that the Warm Springs Ponds were constructed in an area considered to be a groundwater discharge area. Because groundwater level data prior to the construction of the ponds is nonexistent, it is difficult to determine what additional effect the ponds have on vertical gradients throughout this area.

5. *There is a discrepancy between the values in Figure 3-23 and those determined from the January, 1988 static water level data included in Appendix B-4 for the following wells:*

*Difference in Water Level Elevations\**

<u><i>Well Nest</i></u>	<u><i>Figure 3-23</i></u>	<u><i>Appendix B-4</i></u>
GW-02S vs. GW-02D	+ 2.1	No data for GW-02S
GW-03S GW-03D	-0.2	-0.4
GW-04 vs. GW-05	-0.5	+ 0.5
GW-12S vs. GW-12D	+ 0.2	+ 0.1
GW-14S vs. GW-14D	+ 0.4	-0.1

- \*      + indicates ground water is under increasing head with depth  
          - indicates ground water is under decreasing head with depth

*Correction of these values as noted would result in a significant reduction in the northern extent of the zero vertical gradient contour shown in Figure 3-23.*

Response: The values plotted on Figure 3-23 are differences in groundwater elevations measured at each paired well location. Figure 3-23 is incorrectly labeled as showing vertical gradients. Figure 3-23 was developed to qualitatively illustrate the vertical component of groundwater movement. Values presented on Figure 3-23





were not intended to quantify the magnitude of the vertical component of groundwater flow.

Groundwater level differences presented on Figure 3-23 for wells GW-02S and GW-02D were calculated using April, 1988 data because monitoring well GW-02D was frozen from January through March, 1988. You are correct, groundwater elevations measured in monitoring wells GW-04 and GW-05 during January, 1988 indicate there was an upward component of groundwater movement at that time. Therefore the northern contour shown on Figure 3-23 would shift slightly to the south.

6. *The dimensionless values indicated as vertical hydraulic gradients in Figure 3-23 are not true gradients. These values represent the changes in ground-water head (dh in feet) with increasing depth below the water table at specific monitoring well locations. A true vertical gradient is defined as  $i = dh/dl$ , or the ratio of the change in vertical head to the distance or length over which the head changes. This figure should be revised to indicate what the data actually represents and to include monitoring well numbers.*

Response: As discussed in the previous response, Figure 3-23 was incorrectly labeled as showing vertical groundwater gradients. Values plotted in Figure 3-23 are differences in head between shallow and deep monitoring wells.

### 3.1.5 Aquifer Testing

1. *The slug test data results do not accurately represent the hydraulic characteristics of the shallow and deeper aquifer systems. The limitations of the slug test method in providing accurate and representative quantification of aquifer hydraulic parameters is well documented in the literature. The results of the extensive slug test program are useful only for comparison purposes or supplemental data when calibrated with multiple well pumping tests.*

Response: We recognize that data derived from slug tests are best used to qualitatively compare hydraulic conductivities. This is how the data were presented and used in the data summary report. Two pumping tests were completed at the Warm Springs Ponds in conjunction with this investigation (WSP-PW-01, and WSP-GW-07S). Aquifer parameters calculated from these pumping tests were used to compare to slug test analyses.

#### 3.1.5.1 Changes to the Original Work Plan

No Comments.





### 3.1.5.2 Presentation of Data/Results

1. *Page 3-43 indicates that calculations performed as part of the analysis of pumping test data are included in Appendix B-6. Such calculations are not included for the determination of the aquifer hydraulic parameters summarized in Table 3-3 (p. 3-44). Consequently, an independent analysis of aquifer test data was performed without benefit of knowing the precise hydraulic equations used to generate the results summarized in Table 3-3. Furthermore, the independent analysis was performed without knowledge of the completion details for the test well, PW-01, or the associated observation wells. Consequently, it was not possible to verify any effects of partially penetrating wells noted in the bottom paragraph on page 3-45.*

Response: Although the calculations used to analyze pumping test data were not presented in Appendix B-6, methods used to calculate aquifer parameters were presented in Table 3-3 and Appendix B-6. These methods are well documented in the literature (Lohman, 1979) and it was assumed reviewers could reproduce the results.

Lithologic and completion logs for well WSP-PW-01 and associated observation wells are contained as Attachment D of this response document.

2. *There is a discrepancy between the values of transmissivity and hydraulic conductivity determined from the Boulton method listed on Table 3-3, and the information presented in the aquifer test data plots (Appendix B-6). Specifically, there appears to be an error in the selection of the Boulton type curve match points indicated in the drawdown curves for wells OW-02S, OW-3S, and GW-07S. For example, based on the Boulton match point data for well OW-3S (Figure B6-1), the calculated transmissivity is approximately 4,240 gpd/ft as opposed to the 31,700 gpd/ft indicated in Table 3-3. The former value was determined by using the following equation developed by Boulton (Lohman, 1979, p. 36) for use with the delayed-yield type curve.*

$$T = \frac{(1.0)Q}{12.57s}$$

- T = Transmissivity in gpd/ft*  
*s = Drawdown determined from type curve match point*  
*Q = Constant discharge rate in gpd*  
*(1.0) = Dimensionless parameters chosen on the type curve are both equal to 1.0*



For OW-3S:

$$s = 2.0 \text{ feet (Figure B6-1)}$$

$$Q = 74 \text{ gpm}$$

$$T = \frac{(1.0)(74 \text{ gpm})(1440 \text{ min/day})}{(12.57)(2.0 \text{ ft.})}$$

$$T = 4240 \text{ gpd/ft (rounded), or}$$

$$T = (4240 \text{ gpd/ft}) / (7.48 \text{ gal/ft}^3) = 567 \text{ ft}^2/\text{day}$$

*Results of our independent analysis of aquifer test data, including a re-evaluation using the Boulton type-curve method indicate a range of transmissivity values from 14,600 to 21,300 gpd/ft, an average transmissivity of 18,000 gpd/ft and an average specific yield of 0.1.*

Response: In regard to the re-evaluation of aquifer test data for observation well WSP-OW-3S, the transmissivity value of 4,240 gpd/ft that you calculated using the Boulton method (Lohman, 1979) is erroneous. Equation 109 (Lohman, 1979, p. 36) yields transmissivity values with units of  $L^2T^{-1}$ , or in this case  $\text{ft}^2/\text{day}$ . Therefore, converting 4,240  $\text{ft}^2/\text{day}$  to gpd/ft results in a transmissivity value of 31,000 gpd/ft.

In regard to your independent analysis of aquifer test data from pumping well PW-01, the range of transmissivity values presented in Table 3-3 (16,500 gpd/ft to 31,700 gpd/ft) is in good agreement with the transmissivity values you calculated (14,600 gpd/ft to 21,300 gpd/ft). Further, our average storage coefficient of 0.07 is in good agreement with your calculated average storage coefficient value of 0.1.

3. *An independent analysis using the Stallman and Cooper - Jacob methods indicted no significant discrepancies with the data in Table 3-3. The drawdown data for well OW-01 is very dubious. Consequently, hydraulic parameter values determined from this data by the Stallman method or any other method are not considered representative. Corrections in the drawdown data indicated in the distance-drawdown curve (Figure B6-5) require an explanation. Without such an explanation there is no way to independently confirm the validity of the distance-drawdown results.*

Response: We agree that aquifer parameters calculated from water level data measured in observation well OW-01 are somewhat anomalous because water levels changes measured in observation well OW-01 were relatively minor. We presented





these data only to include all data collected at all observation wells during the investigation.

Aquifer parameters calculated using the distance-drawdown method were in good agreement with values calculated using other methods and are therefore considered viable. Exclusion of aquifer parameter values calculated using the distance-drawdown method does not change the range of values presented in Table 3-3.

4. *The ground-water flow calculations presented in the Technical Memorandum, dated May 19, 1988 (Appendix B-6) are invalid because they are based on slug test data. The average value of aquifer transmissivity calculated from slug test data (1855 gpd/ft) is an order of magnitude lower than that calculated from multiple-well pumping test data (18,000 gpd/ft, comment #2, above). As stated on the bottom of page 3-43, "Slug test data probably provide for lower hydraulic conductivities due to insufficient well development, lack of stress on the aquifer, and limitations in the slug test technique". Consequently, use of slug test data for numerical modeling of ground-water flow is inappropriate.*

Response: Groundwater flow calculations presented in the Technical Memorandum dated March 19, 1988 were revised using aquifer parameters calculated with pumping test data. The revised calculations (Memorandum from Patrick Dunlavy to John Lincoln, July 20, 1988) are included as Attachment F to this response document.



## 4.0 POND BOTTOM SEDIMENT INVESTIGATIONS

### COMMENTS

#### 4.1 METHODS

1. *A schematic of the drilling and sampling apparatus should be included in this section. A discussion of the degree of unsetting and mixing of sludge layers observed or anticipated using this sampling device should be provided.*

Response: Brochures and photographs of the drilling and sampling apparatus used to complete pond bottom sampling at the Warm Springs Ponds are available from Vibra-Core Drills Ltd., #1-12342-82A Avenue, Surrey, B.C., Canada V3W OL6.

We can only offer a qualitative explanation of the degree of unsetting and mixing of sludge layers which occurred during sampling using the Vibra-Core sampling device. In general, the pond bottom sediments in submerged portions of Ponds 1, 2, and 3 exhibited increasing density with depth. The sampling methodology involved first determining the depth to the top of the pond bottom sediments from a designated measuring point on the pontoon platform. This provided a control point with which determinations of sampling depths and percent retrieval could be evaluated.

The deepest interval in the bottom sediment profile was sampled initially. Because the deeper materials were relatively competent, we are confident that the degree of settling and mixing in samples collected from deeper than about five feet below the top of the sediments was minimal. We base this judgment on the fact that we generally were able to obtain 100% retrieval in the core tube from these depths.

The degree of settling and mixing tended to increase in samples obtained from the upper five to seven feet of the bottom sediment profile. The upper material was typically highly saturated and was either in a flocculated form or exhibited a gel-like consistency. In some cases, a vegetative mat was present at the top of the bottom sediments. Core recoveries were generally less than 75% in this zone and occasionally were as little as 50%. This information was noted in project field books. Depth intervals for samples obtained from the upper zones and which were subsequently shipped to the laboratory were determined by distributing the measured sampling interval over the length of core recovered.





## 4.2 CHANGES TO THE ORIGINAL WORKPLAN

1. *An explanation should be provided as to why the first set of samples analyzed for EP Toxicity could not be validated. A discussion of how the results are likely to be affected by using archived samples should be provided.*

Response: Several of the acceptance criteria for validating the first set of EP Toxicity data were not met by the CLP laboratory performing the analyses. The problems with this data set were of sufficient magnitude to make the data unusable. We are not aware of any holding time requirements for material samples with regard to EP Toxicity analyses. Because of this, we believe laboratory analysis of archived samples is prudent and the resultant analytical data are valid.

## 4.3 PRESENTATION OF DATA/RESULTS

1. *The analytical parameters for pond sediments listed in Table 4-1 include particle size distribution. However, the results of this analysis are not found in the report or in the Appendix. These should be included.*

Response: Numerous samples were collected and submitted to a CLP laboratory for analysis of particle size distribution. Particle size data were unable to be validated and were not presented in the data summary report.

2. *Sulfate should have been included as one of the analytical parameters since the presence of precipitated calcium sulfate could be a significant contributor to pond bottom sediments. Also, sulfide is listed as one of the analytical parameters, but the results for sulfide do not appear in the statistical summary in Table 4-2. These should be incorporated in the report.*

Response: Sulfate is not included on the parameter list for RAS analyses used during this investigation. Analysis of this parameter will be completed on pond bottom sediment samples if it is determined these data are necessary to complete future site activities. Statistical manipulation of sulfide data for samples collected from pond bottom sediments will also be completed if such analyses are necessary.

3. *The percentage of solids found in sediments and its distribution within the pond system is an important parameter to study especially when selecting remedial alternatives. The RI makes little use of the percentage of solids data generated. A qualitative statement on page 4-19 says that core samples have a very broad range of percentage solids and range in texture from a dispersed solid through a gel-like consistency to a solid. This statement should be substantiated with a series of diagrams showing solids v. lithologic*





zone for each pond. An analysis of particle size distribution and density should also be included.

Response: Evaluations of percentage solids data were completed, as necessary, in conjunction with the site public health and environmental assessment and the site feasibility study.

4. *The percent solids data in Table 4-2 do not agree with those values listed in Appendix C-2A. The data in the Appendix indicate an average that is much higher. A comparison should be made of these data and the correct values should be indicated.*

Response: The statistical values reported for percent solids on Table 4-2 are erroneous. Reported values appear to be a duplication of values reported for cyanide values located on the line above the percent solids data. Percent solids data contained in Appendix C-2A are correct. Corrected statistics for percent solids data by pond are presented below.

SUMMARY OF PERCENT SOLIDS DATA  
FOR POND BOTTOM SEDIMENTS (%)

Number of Samples	Minimum	Maximum	Average
POND 1			
28	37.4	92.1	64.8
POND 2			
34	13.6	87.9	55.1
POND 3			
49	9.1	89.1	37.4
WILDLIFE PONDS			
3	53.8	75.6	67.8

5. *In addition to metals, cations and anions were analyzed in many samples. However, the investigation fails to utilize most of these data to support or supplement results from sediment analysis.*

Response: Cation and anion data were evaluated, as necessary, to complete the site public health and environmental assessment and site feasibility study.



6. *The surface water treatability study (Section 2.4) went through a good deal of effort to generate and analyze sludges produced from sediments and precipitated metals. This information should be utilized and compared with the characteristics of sediments found in this section.*

Response: See our response to comment No. 1, Section 3.8 of the treatability section of this response document. We expect that there would be significant differences between the treatability sludges and the pond bottom sediments. A component of the pond bottom sediments originated as suspended solids from Silver Bow Creek under a wide variety of flow conditions. Additionally, the composition of the pond bottom sediments is affected by the biological activity in the ponds. The sludges produced in the treatability tests represent only the results of chemical treatment with little influence from suspended solids in Silver Bow Creek.

7. *From a treatability standpoint, the following type of information should have been addressed in the treatability study and in the pond sediment investigations performed as part of the RI:*
- o Establishing which lithologic layer(s) newly precipitated metals and sediments are likely to fall into.*
  - o Determining the degree to which increased surface velocities in the pond are likely to transport pond sediments and which type of sediments are most likely to be transported.*
  - o Determining the settling rates for different layers of sediments and comparing the results with those obtained in the treatability study.*

Response: The four lithologic layers that were identified in each of the ponds are primarily an effect of the geochemical conditions present in the ponds. Pond 3 was constructed in the mid 1950's and was converted from a sedimentation pond into a treatment pond in 1967. Hence, metal precipitates have contributed to the pond bottom sediments for approximately 23 of the 35 years of operation. The metal precipitates have most likely been incorporated into all the lithologic layers above the original ground surface.

Determination of the degree to which increased surface velocities in the pond are likely to transport pond sediments was not included in the work plan for the Phase II RI. Samples were collected for particle size determinations but we were unable to validate these data. It is our understanding that ARCO is completing these types of analyses and results from these efforts should satisfy your concerns.





The layers of sediments in the ponds are composed of sediment and tailings that have been carried down Silver Bow Creek to the ponds as suspended solids. Also contained in the pond bottom sediments are metal precipitates and organic material from biological processes within the ponds. It would be very difficult to determine what the original settling rates were of the pond sediments because the precipitated and organic material could not be redispersed into its original particle characteristics (precipitate size, effective density, shape, etc.).

8. *A plot of metals concentrations versus pond location should have been included to permit an evaluation of where individual metals are likely to be distributed.*

Response: These types of plots were completed in draft form and were not included in the remedial investigation report because identifiable trends in the spatial distribution of metals could not be distinguished. The data are amenable to this type of evaluation and further analysis of the data in this manner will be completed, as necessary, in support of the site feasibility study.

9. *Page 4-11 discusses the estimated accumulated pond bottom material. The methods and assumption used in calculating these volumes should be included in the text.*

Response: Volume estimates of accumulated pond bottom material were calculated using the pond bottom sediment isopach map (Figure 4-5) in conjunction with the pond bathymetric map prepared during the Phase I RI (MultiTech, 1987). Areas between isolines were determined using a polar planimeter and multiplied by the average thickness of material. The average thickness of material between each two isolines was half the sum of the values associated with the each two adjacent isolines.

10. *Page 4-18 mentions that the average pH of pond 3 bottom sediments is 8.2 and is probably due to the addition of lime to Silver Bow Creek. Data or evidence to support this conclusion should be provided. Samples from ponds should be analyzed for calcium oxide (quick lime) to determine site specific affects of undissolved lime on the pond system.*

Response: The statement made in the data summary report represents a probable explanation of the variability of pH in bottom sediments within the pond system. Other factors may also explain the measured variability. Further data interpretation and/or additional sampling and analysis will be completed, if necessary, to support analysis of alternatives during the feasibility study.



11. *Organic analyses discussed on page 4-22 detected bis(2-Ethylhexyl) Phthalate in samples from ponds 2 and 3. The presence of this compound may be due to laboratory contamination. Trip and reagent blanks should be double checked for the presence of this compound.*

Response: The presence of this compound is commonly associated with laboratory contamination, particularly at levels measured in samples collected from Ponds 2 and 3. The trip blank which accompanied natural samples was only analyzed for volatile compounds, and hence offers no more information regarding the source of this compound.

12. *Appendix C-2B contains data on rinseates from pond bottom sediments. The purpose and relevance of this data should be incorporated into the report.*

Response: These data represent analyses of water blanks and bottle blanks used for data validation purposes.



## 5.0 EXPOSED TAILINGS/CONTAMINATED SOIL

### COMMENTS

#### 5.1 MILL-WILLOW BYPASS SOIL SAMPLING

1. *The stated purpose of this task was to gain a better understanding of potential sources of metals contamination believed to be responsible for acute fish kills associated with the Mill-Willow Bypass and to define the source, nature, and extent of metals contamination in soils and tailings along the bypass. However, this section includes no mention of the establishment of background concentrations of any target metals in soils for determining what concentration ranges were considered indicative of soil contamination. The introductory paragraph to Section 5.0 indicates that several samples were obtained from upland areas, adjacent to the OU, to provide a basis for evaluating the magnitude of metals concentrations measured within the OU. Since background metal concentrations in soils or other criteria for determining soil contamination were not specifically presented for comparison with those in soil along the bypass, the resultant data is useful only as an indicator of potential source areas of metals contamination in the bypass. Evaluation of any remedial action alternative requires proper distinction of contaminated versus uncontaminated soils. As addressed further below, the Phase II RI fails to clearly delineate the areal and vertical extent of tailings and contaminated soils along the Mill-Willow Bypass.*

Response: The Phase II RI was not designed to determine background concentrations of metals. As you stated, the intent of the Mill-Willow Bypass soils investigation was to collect sufficient data to identify probable source areas of metals along the surface water course. Issues related to background metals concentrations and contaminated versus uncontaminated soils will be evaluated during the site feasibility study and record of decision.

##### 5.1.1 Methods

###### 5.1.1.1 XRF Survey

1. *The description of the XRF survey method used is incomplete. No literature is cited for the particular method used, or a description of applicable data analysis procedures, or method limitations. This same type of information is also absent from the FOP and the QAPP. No information is provided in the RI report that indicates that all XRF activities, including data collection and interpretations were under the control of a centrally managed QA program. Since there are no documented assurance parameters that define the acceptable quality of the XRF data, the data have limited value and are useful only as a general indicator of specific metal concentrations in soil materials. As such, these data are unacceptable as a sole source of information on which to base the delineation of contaminated soils as opposed to uncontaminated soils.*





Response: XRF analyses of samples collected along the Mill-Willow Bypass were completed using an Aurora Tech TX 100 XRF in accordance with procedures described in the project FOP. As stated in the data summary report, the XRF was used during the Phase II RI as a screening tool to help direct sampling efforts. The data are amenable to validation and such efforts to validate the XRF data will be completed, if necessary, to support development of alternatives during the site feasibility study. Numerous soil samples were also collected from the Warm Springs Ponds Operable Unit for laboratory analysis. These data were used in conjunction with qualitative determinations of metals concentrations using the XRF to determine the spatial and vertical distribution of metals in soils at the site.

2. *The last paragraph of this section indicates that the XRF data were used to establish the spatial variability of metals concentrations in soil materials along the bypass. However, there is no mention of whether this effort included establishment of background data. Moreover, 50 soil sampling locations were selected based on the survey data without the prior establishment of whether XRF data were representative of metal concentrations in samples analyzed. Proper interpretation of XRF data from a target area requires prior calibration to background soil conditions, including correlation of the data with total concentrations of the index metals in background samples. The Standard Operating Procedure for XRF use and calibration in the FOP (NETSOP-23) requires calibration involving a comparison of peak area values with background levels. There is no information provided in the RI report that documents the completion of such a comparative analysis.*

Response: The XRF was used to obtain index values in the field. Based on these index values, sites for collection of samples for laboratory analysis were chosen that represented relatively high, medium and low index values. These sites were sampled and analyzed with both XRF and by a CLP laboratory. Regression analyses were then performed to obtain regression equations that could convert the index values to concentrations. It is understood that the quality of the XRF data is not the same as CLP laboratory data. XRF index values can be converted in the field to concentrations using relationships developed between the instrument and known standards. Alternatively, XRF index values can be recorded and later compared to received laboratory data. The latter procedure was used to complete soil sampling in the Mill-Willow Bypass.

3. *No details are provided to indicate exactly how the 50 soil sampling sites were selected based on the results of XRF survey data. A discussion of the selection criteria used for both the soil sampling sites and the background data sites should be provided. Details as to how the XRF data were used to delineate between contaminated soil, tailings and uncontaminated soil should be provided.*



Response: The 50 soil samples shipped to the CLP laboratory for analysis were selected based on the relative XRF index values determined through the initial XRF survey of the channel. Those samples selected represented a range of index values measured and provided for thorough geographic coverage of the Mill-Willow Bypass. The XRF data were not specifically used to differentiate between contaminated soil, tailings, and uncontaminated soil. The data were used to qualitatively determine depth and breadth of metals contamination by evaluating trends in the data from samples collected both spatially and from a vertical profile. Where XRF values decreased measurably on a relative basis (typically by 100%), this width or depth was used to approximate the extent of metals contamination.

#### 5.1.1.2 Soil Sampling

1. *Soil sampling was only completed within the depth interval of 0 to 1 inch. It would have been appropriate to collect samples at several depth intervals since this would have provided a much better characterization of the vertical distribution of metals within the exposed tailings and underlying soils.*

Response: Soil sampling in the vicinity of the Mill-Willow Bypass was completed in accordance with the project field operations plan. The rationale stated in the field operations plan for sampling the 0 to 1 inch interval was to identify potential metals contaminant sources believed to be responsible for historic fish kills in the area. The original focus of this component of the remedial investigation was not on characterizing the vertical extent of metals within exposed tailings and underlying soils. A general understanding of the vertical extent of metals in soils was obtained during subsequent studies associated with the remedial investigation wherein data were collected for this purpose.

2. *Measurements of tailing thickness made at various sampling locations are not presented. This information should be presented either in a summary table or directly on Figure 5-1 since it is necessary in order to verify calculations of the volume of tailings along the bypass.*

Response: Measurements of tailing thickness made at various sampling locations along the Mill-Willow Bypass are presented on the following table.





MILL-WILLOW BYPASS MAIN CHANNEL			
LOCATION	ESTIMATED THICKNESS (FT)	LOCATION	ESTIMATED THICKNESS (FT)
42+50	3.0	125+40	1.0
44+50	3.0	135+20	2.0
50+00	4.0	148+00	1.8
55+00	2.0	158+00	2.0
62+50	3.0	185+00	2.0
65+00	3.0	195+00	2.0
70+00	5.0	201+00	1.0
75+00	5.0	217+00	0.5
80+20	1.5	230+00	0.0
83+00	3.5	250+00	0.0
90+00	2.7	270+00	0.0
95+00	3.0	292+00	2.0
98+00	2.8	295+00	3.5
105+20	1.5	298+00	4.3
115+10	2.0		
DIVERSION CHANNEL			
1+20	2.0		
4+50	3.0		

Locations shown on Figure 5-1.

### 5.1.2 Changes to the Project Work Plan

1. *This section indicates that no changes to the project work plan resulted from the XRF surveys and soil sampling along the bypass. However, a comparison of the soils/sediments parameters list in Table 3-5 of the FOP with the parameters determined during the RI indicates a significant discrepancy between the two lists. Several more parameters were measured during the RI than were included in the FOP parameter list. The report should be revised to include an explanation of why the parameter list was expanded during the Phase II RI.*



Response: The EPA Contract Laboratory Program (CLP) was used for analytical services. A routine analytical service (RAS) analysis for total metals has an established parameter list, which contains metals of interest listed in Table 3-5. The RAS analysis for total metals was utilized because known parameters of interest are included and additional information on the concentration of other metals in sediments may be useful in evaluation of the site.

### 5.1.3 Presentation of Data/Results

1. *The results of the laboratory concentrations and XRF index values for arsenic, copper, iron, lead, manganese, nickel, and zinc determined from the 50 samples collected along the Mill-Willow Bypass were not correlated in this section. Such a correlation was performed for sediment samples collected elsewhere in the OU and the results are presented in Section 5.2.3. An independent linear correlation analysis was performed to evaluate the relations between XRF index values and laboratory concentrations for arsenic, copper, iron, and zinc determined from the 50 samples of soils and tailings. The results of the analysis are summarized below.*

<i>Element</i>	<i>Correlation Coefficient (r)</i>	<i>Standard Error of Concentration Estimate</i>	<i>Equation*</i>
<i>Arsenic</i>	<i>0.28</i>	<i>70</i>	<i>C = 258(XRF index) - 7.7</i>
<i>Copper</i>	<i>0.97</i>	<i>1,180</i>	<i>C = 3274(XRF index) - 1752</i>
<i>Iron</i>	<i>0.45</i>	<i>11,454</i>	<i>C = 6211(XRF index) + 19674</i>
<i>Zinc</i>	<i>0.94</i>	<i>3,464</i>	<i>C = 8207(XRF index) - 5150</i>

\* C = Estimated concentration

*The correlation analysis indicates that XRF index values for copper and zinc correlate relatively well with laboratory concentration data. However, based on the high values for the standard error of concentration estimated by the equations, XRF index values are not good predictors of actual concentrations of copper and zinc in field samples. The XRF index values for arsenic and iron do not correlate well with laboratory concentration data. The significance of these results is that although XRF survey data may be useful to identify sediments contaminated with relative high concentrations of certain metals, provided that the data are properly compared with background concentration levels, they have very limited usefulness as predictors of metal concentration levels.*

Response: The soil samples taken along the Mill-Willow Bypass for laboratory analysis represented a broad range of soil types, as presented in Table 5-3 of the





Data Summary Report. Combining values from silts and sands for the regression analysis between XRF and laboratory data is acceptable because the structural matrixes are comparable. However, the metallic salts that were analyzed have a completely different structural matrix and will respond differently to XRF analysis. It is therefore not appropriate to combine the metallic salts with the soil samples when performing the XRF to laboratory correlations. These different matrices should have separate correlations performed.

Generally much better correlation coefficients and reduced standard error are achievable when multiple linear regression techniques are used. This is due to the spectral overlap of many of the elements that are of interest in this study. These overlaps include copper and zinc, iron and manganese, and arsenic and lead. A considerable amount of error may be introduced into the equations by not taking these other elements into consideration. Further breakdown of the data by type of matrix may decrease the standard error of concentration estimates to levels which would make the predictions more meaningful.

2. *No laboratory gradation analyses were performed on soil samples collected along the Mill-Willow Bypass as was done for samples collected in other areas of the OU. These should have been done since they provide a more meaningful correlation between soil type and metals concentrations than visual estimates of texture.*

Response: Several samples were obtained from the Mill-Willow Bypass area for gradation analysis. These data were unable to be validated and hence, were not presented in the data summary report. Therefore, no verifiable gradation analyses are available for soils and tailings located along the Mill-Willow Bypass.

3. *The statistical soil analytical data summarized in Tables 5-2, 5-3, and 5-4 provide an indication of the areal variability of metal concentrations along the bypass and variability in relation to material type and geomorphic units. However, there is no discussion of the variability of metal concentrations in relation to background concentrations. Moreover, this section does not include a map that delineates specific areas the investigators determined to be source areas of metal contamination along the bypass. A clear delineation of source areas relative to some background level criteria is required to properly evaluate the areal and vertical extent of alleged metals contaminated soils and tailings, especially since the statistical summaries indicate a very wide range in metal concentrations with respect to material types and geomorphic units.*

Response: Because background concentrations of metals and soils were not evaluated during the Phase II RI, no discussion is included in the data summary report on the variability of metal concentrations relative to background. A map delineating source areas along the bypass was not included in the data summary





report because the scale of such a map for the channel was not conducive to presentation. This map is available from MDHES and will be provided to the commentor upon request.

4. *Based on the results of this investigation, it was estimated that 130,000 cubic yards of contaminated soils exist along the Mill-Willow Bypass. However, the methodology used by the investigators to arrive at this volume of contaminated soil based on samples collected from only the upper inch are not included in this section or in Appendix D. Without this information, an independent analysis cannot be performed to verify the accuracy, completeness and representativeness of the volume estimate. The report should be revised to include a detailed discussion of the methodology used to determine the volume of contaminated soil. This is important because any significant inaccuracies in the estimate of such large volumes of contaminated soils will be reflected in the risk assessment and the evaluation of any remedial action alternatives and associated cost analysis.*

Response: The volume of contaminated material within and adjacent to the Mill-Willow Bypass was estimated using both thickness and map data. Contaminated material was identified as tailings which typically included yellow to brownish-orange sand- and silt-sized material. Tailings thicknesses were determined visually in several borings along the bypass. The base of tailings material in the boreholes was identified as the bottom of oxidized sand and silty sand overlying organic silt or sandy gravel. The table presented in response to question No. 2 of section 5.1.1.2, above, provides measured thicknesses of tailings material encountered in the soil borings or measured on cut-slopes along the active channel.

The areal extent of tailings material along the bypass was determined by mapping the extent of exposed and vegetated tailings material at a scale of 1:200 (see response to Comment No. 3, above). Attachment G contains calculations which were used to determine volume estimates from areal and thickness data collected.

## 5.2 WARM SPRINGS PONDS AREA EXPOSED SEDIMENT SAMPLING

1. *The objectives of this study are stated as follows:*
  - o Collect sufficient data to semi-quantitatively identify the areal and vertical extent of tailings and contaminated soils of tailings and contaminated soils in exposed and partially vegetated areas of the Warm Springs Ponds OU which exceed metals concentrations that may pose an unacceptable risk to human health.*
  - o Determine the approximate volume of material within the OU which is contaminated and may pose an unacceptable risk to human health.*



*Several tables showing the results of XRF and laboratory analyses of sediments are presented in this section. However, no information or guidelines are provided which would indicate how the decision was made to classify these materials as contaminated soils or as soils which may pose an unacceptable risk to human health.*

Response: The decision to classify soils as contaminated versus uncontaminated was made during the RI by comparing relative concentrations in samples obtained from various locations. In general, the areal extent of soils contamination was determined by comparing parameter-specific concentrations in surface soils on-site to those concentrations measured in samples obtained from upland areas, east of the pond system. Areas where on-site concentrations exceeded the upland sample concentrations or were visually identifiable as exposed tailings materials were included in the acreage estimate of contaminated soils. The vertical extent of metals contamination in site soils was defined as the point where the data indicated a marked decrease in parameter-specific concentrations. This point in the soil profile was typically evident as a decrease in metals concentrations on the order of one-half to one-quarter the concentrations measured in overlying materials. Further analyses of those concentrations that constitute a threat to public health and the environment were completed in conjunction with the site feasibility study and PHEA.

#### 5.2.1 Methods

No Comments.

##### 5.2.1.1 XRF Survey

1. *This section indicates that the XRF instrument was calibrated with existing soil samples for which a range of metals concentrations had been determined by an analytical laboratory. The results of this calibration procedure including a comparison of XRF index values to laboratory analyses are included in the RI report. Confirmation that proper calibration procedures were completed is not possible without the appropriate documentation.*

Response: Calibration of the XRF was performed following NETSOP-23 which is contained in the project field operations plan. Prior to use and at regular intervals during use, the XRF instrument was calibrated using internal factory standards. Peak area counts for material samples with known metals concentrations were compared and contrasted. Index values recorded during calibration procedures are not necessary to evaluate the accuracy and/or precision of the XRF instrument for estimating metals concentrations in samples collected at the site.





Calibration results presented in the Phase II RI use XRF and laboratory data which were obtained from material samples collected from the site. These data can and were used to independently evaluate the accuracy of the XRF in estimating metals concentrations in site materials.

#### 5.2.1.2 Soil Sampling

No Comments.

#### 5.2.1.3 EP Toxicity

No Comments.

#### 5.2.2 Changes to the Original Work Plan

1. *Soil analyses included several additional parameters that were not included in the FOP (Table 3-5). The reasons for including the additional parameters requires an explanation.*

Response: Soil samples were analyzed through EPA's CLP for routine analytical services (RAS) parameters. All parameters included in the FOP are included in this standard analysis. Although the RAS list includes more parameters, the cost for completing the RAS analysis was less than that charged for completing the less intensive parameter list included in the FOP.

#### 5.2.3 Presentation of Data/Results

1. *There is a discrepancy between many of the laboratory concentrations presented in Table 5-5 and the analytical data in Appendix D-4. The most notable discrepancy is in the concentration of iron in the sample collected from site WSP-SO-411A. The concentration of iron in Table 5-5 is 60,800 mg/kg as opposed to 22,000 mg/kg in Appendix D-4.*

Response: Data presented in Table 5-5 are original laboratory data. Data presented in Appendix D-4 are concentrations which were revised following data validation procedures. A revised Table 5-5 containing validated data is included as Attachment H to this response document. Also, the concentration of zinc in sample WSP-SO-402A in Appendix D-4 should be changed to 2580 mg/kg from 52.8 mg/kg.

2. *An independent correlation analysis of the soils analytical data and XRF index values was completed to check the results presented in Table 5-5. The results of the analysis indicated the following correlation results:*



Arsenic	$r = 0.75$	Standard Error of Concentration Estimate = 210
Copper	$r = 0.92$	Standard Error of Concentration Estimate = 1,391
Iron	$r = 0.76$	Standard Error of Concentration Estimate = 20,874
Zinc	$r = 0.89$	Standard Error of Concentration Estimate = 1,668

*XRF index values for arsenic and iron do not correlate well with analytical data. There is relatively good correlation of XRF index values for copper and zinc with analytical data. The relatively high standard error of concentration estimates indicate that XRF index values are not good predictors of actual metal concentrations in field samples. Therefore, XRF data should not be used to delineate areas where metal concentrations in soils may exceed health risk thresholds.*

Response: XRF and laboratory data were not used in the Phase II RI report to delineate areas where soil metal concentrations may exceed health risk thresholds. This level of analysis was completed, as necessary, to support preparation of the site feasibility study and PHEA. We do not believe it is prudent to exclude XRF data in their entirety from any analyses which require a certain level of quantification. As stated in our response to Comment No. 1, Section 5.1.3, the relatively poor correlations you present for arsenic and iron, for example, may be a function of grouping all the XRF data into one data set. The physical variability of the material analyzed with the XRF and the laboratory suggests that correlations between XRF and laboratory data should be developed on a matrix-specific basis. This effort may result in better correlation coefficients for certain metals and thereby make the XRF data more quantifiable with respect to the variety of applications.

3. *A summary of XRF index values above and below the bottom of exposed tailings/contaminated soils is presented in Table 5-6. This table should be modified to include the corresponding depths at which changes in XRF index values occur.*

Response: Depths at which changes in XRF index values occur are shown on boring logs contained in Appendix D-7.

4. *Statistical summaries of laboratory analytical data for surface (0 to 1 inch) samples obtained from upland areas east of and above the valley bottom and from exposed tailings areas within the OU, were developed and presented in Tables 5-7 and 5-8. Based on these data, it is stated that mean concentration of measured metals in samples obtained from tailing sites within the OU are generally greater than average concentrations in samples collected from the upland areas. It should be noted that data from only 3 to 4 samples of the upland soil were used to develop Table 5-7, and data from 7 samples of the exposed surface tailings were used to develop Table 5-8 since the mean and average values were computed based on very limited data set (3 to 7 samples) collected over a very large area, the results may not be statistically valid.*





Response: Your statement is correct. Additional samples will be collected and analyzed if the need arises to provide statistically valid comparisons of metals concentrations in soils in upland areas versus valley bottom areas within the operable unit.

5. *Figure 5-4 is an isopach map showing the thicknesses of contaminated materials in exposed areas of the OU. This figure was developed using both XRF and laboratory data for arsenic, copper, zinc and iron. The location of sampling sites is indicated by a circle on this figure and a thickness value is given next to the circle. Nowhere in this section is information provided on the variation of metal concentration with depth or as to how this "representative thickness of soil contamination" was arrived at. Consequently more discussion should be provided with respect to the various steps employed in developing Figure 5-4.*

Response: Depth of tailings/contaminated soils shown on Figure 5-4 were determined from field observations of material encountered in each boring. Boring logs present in Appendix D-7 contain field descriptions of materials encountered and corresponding XRF data. Arrows on the left side of the lithologic logs indicate the depth of tailings/contaminated sediment for each boring which was determined in the field. In general, field observations of the depth of tailings/contaminated soils correlate with a decrease in XRF index values, indicating a decrease in contamination levels. XRF and laboratory data were occasionally used to modify the depth of tailings/contaminated soil in a boring.

6. *It should be noted that the results of the EP Toxicity tests indicate that most of the tailings/contaminated soils samples analyzed do not exceed maximum concentrations established for the test by EPA.*

Response: This statement is made on page 5-19 of the data summary report. However, water soluble metals concentrations for many of the tailings and soils samples collected from the Mill-Willow Bypass area are much higher than maximum concentrations established for the EP Toxicity test.





## 6.0 DATA VALIDATION SUMMARY

### COMMENTS

1. *There is confusion among the terms contract compliance screening, data validation, and data assessment. Data validation is the process of examining a data package to ensure that analytical methods, instrument calibrations, laboratory quality control check samples, adherence to quality control limits and assignment of flags, and all calculations and transcriptions were carried out by the laboratory according to the provisions of the QA Project Plan and the Laboratory Analytical Protocol. The term contract compliance screening was first used to describe the protocols used by the U.S. EPA Sample Management Office (SMO) to validate data packages in accordance with the various Contract Laboratory Program (CLP) statements of work (contracts). Data validation and contract compliance screening are often used synonymously. But for projects in which the analyte list extends beyond those of the CLP, contract compliance screening becomes a subset of data validation. The two processes become identical if the QC program (QC checks, control limits, and corrective actions) of the CLP is extended to cover all of the non-CLP analytes. Data assessment is the process of examining a validated data package to determine if the presence of laboratory flags either does not impact data quality or requires data to be qualified as estimated or rejected. Data assessment usually involves assigning a new set of qualifier flags that indicate the outcome of the assessment process. Data should be presented with both the laboratory flags and the assessment qualifiers.*

Response: In general, we agree with the reviewer's comments.

### 6.1 INTRODUCTION

No Comments.

### 6.2 CONTRACT COMPLIANCE SCREENING

1. *This section combines data validation and part of data assessment. The "second level of data validation and reduction" is actually data assessment and should be included in Section 6.3. The title of this section should be changed to "Data Validation".*

Response: We agree with the reviewer's opinion that a more descriptive title for Section 6.2 would be "Data Validation".

2. *The cited "Functional Guidelines" document emphasizes data assessment and is out of date. More appropriate documents for use in data validation (contract compliance screening) are Standard Operating Procedure for Contract Compliance Screening (CCS)*



*of Routine Analytical Services Analyses of Inorganics [Organics] Data Under SOW No. 787. The assessment process should be referenced to Laboratory data Validation, Functional Guidelines for Evaluating Inorganics [Organics] Analyses as published in 1988. These documents have superseded the 1985 "Functional Guidelines".*

Response: The first document cited by ARCO is used exclusively by EPA's Sample Management Office to assess contract compliance for analytical work performed by CLP laboratories. This assessment is conducted for RAS (Routine Analytical Services) only. These assessments were made for all RAS data collected during the Warm Springs Ponds Phase II RI. Data generated under CLP SAS (Special Analytical Services) do not undergo contract compliance screening by SMO. All data (both RAS and SAS) generated during the Phase II RI were assessed using the 1988 Functional Guidelines documents and EPA Region VIII Data Quality Assurance Review forms and Region VIII guidance as provided by the Deputy Project Officer (DPO) for CLP in the Region's Environmental Services Division.

### 6.3 DATA VALIDATION, REDUCTION, AND QUALITY ASSURANCE STATEMENTS

1. *This section details the procedures used to arrive at the data quality assessments of accuracy, precision, representativeness, completeness, and comparability. The section should include the data assessment test that is presented in section 6.2.*

Response: Section 6.3 contains detailed definitions of the PARCC (precision, accuracy, representativeness, completeness and comparability) parameters. It describes each parameter and what QC samples were specifically used to quantify each parameter. It also references appropriate statistical methods presented in the project QAPP document. The last five bullets in Section 6.2, page 6-3, summarize the contents of the data validation/assessment documents which were prepared for this Remedial Investigation.

#### 6.3.1 Accuracy

1. *The results of the analysis of Laboratory Control Sample (LCSs) is an additional tool for the assessment of accuracy that should be included. These results can be particularly valuable if another accuracy QC check is just outside control limits. In such case, excellent recoveries for the LCSs may favor not assessing the affected data as estimated.*

Response: We agree that the results of the analysis of the Laboratory Control Sample (LCS) is an additional set of information that may be used to assess accuracy. These standards are generally provided by EPA and are "well known" by the laboratory. If the laboratory fails to perform within the contract window (80-120%





for aqueous LCS; limits set by EPA for solid LCS), they are required to redigest and reanalyze all associated samples. As a consequence of this heavy penalty, laboratories rarely report data for the LCS outside the control window(s). In some cases, the aqueous LCS may actually be the initial calibration verification solutions. As such, these solutions represent another calibration and may not relate well to "real samples". The acceptable control windows established by EPA for the solid LCS are often times very wide for most analytes. Lastly, for many SAS analytes no LCSs are available. For these reasons, we have not chosen to use LCS data for the assessment of accuracy. We have, instead, used results of laboratory matrix spike analyses and results of standard reference material determinations (EPA, NIST, etc.) that are not "well known" to the laboratory. These samples are submitted "blind" to the laboratory. In some special analytical services (SAS) requests, we have stipulated that a certain reference standard is to be used by the laboratory as an LCS. These may be used as additional data for the assessment of accuracy.

### 6.3.2 Precision

No Comments.

### 6.3.3 Representativeness

1. *Using the results of blank analyses as a measure of representativeness is arbitrary. Blanks are more appropriate for assessing accuracy. In the sense used here, all QC checks affect representativeness because any out-of-control QC statistic would be indicative of one or more analytical result being "not representative" of the "true" result. If it is desired to make some statement about representativeness based on QC checks, it is best to use the field triplicates. This follows the recommendation in Data Quality Objectives for Remedial Response Activities, Vol. 1 - Development Process (EPA 540/G-87/003A, page 4-25):*

*Representativeness can be assessed by the use of collocated samples. By definition, collocated samples are collected so that they are equally representative of a given point in space and time. In this way, they provide both precision and representativeness information.*

Response: In Quality Assurance of Chemical Measurements (Lewis Publishers 1987), Taylor defines representativeness as "degree to which the data accurately and precisely represent a characteristic of a population parameter, variation of a property, a process characteristic, or an operational condition". In the document Data Quality Objectives for Remedial Response Activities, Vol. 1 - Development Process (EPA 540/G-87/003A) a similar definition is provided. Representativeness is difficult to quantify because it is dependent upon a properly designed and implemented sampling



scheme. The rationale and justification of the sampling design is provided in several planning documents including the Work Plan and the Field Sampling Plan part of the Sampling and Analysis Plan.

Representativeness is accomplished by choosing the number of samples, locations, and using sampling procedures that will depict the matrix and conditions being measured. One aspect of representativeness is quantifiable. Potential contamination resulting from sampling is bias which impacts representativeness. If contamination is significant, then samples may not be truly representative of what is measured. Quality control samples used to assess bias from contamination are field blanks. This bias also affects accuracy and precision. Collocated samples, which were not used in this RI, can provide precision and representativeness information, but cannot provide data relating to bias resulting from field contamination.

#### 6.3.4 Completeness

1. *In the equations for completeness, the term "valid sample" needs to be defined. U.S. EPA Region 8 uses several different levels of completeness. Their definition of "valid sample" can range from data with no qualifiers to all non-rejected data.*

Response: A valid sample is one that does not have rejected data.

#### 6.4 SUMMARY OF QUALITY ASSURANCE STATEMENTS

1. *The lack of a formal QC report makes it impossible to correlate the tables of summary QA statements with the data tables in the appendices. Also, there is no discussion of the decisions used to assign the assessment qualifiers (J,E,R, etc.). The assignment of these qualifiers does not always have to be automatic. For example, for soils, a duplicate RPD greater than  $\pm 20$  percent results in a laboratory flag of "\*". However, the EPA Functional Guidelines document allows a control limit of  $\pm 35$  percent RPD before assessing the data as estimated and adding the qualifier "J". Also, some decisions are left up to the "best scientific judgement" of the reviewer. In addition, several QC checks (e.g., ICP serial dilution) that can result in both laboratory flags and data assessment qualifiers are not included in the summary QC tables. Thus the data tables in the appendices can contain results that are flagged or even rejected, with no QC information to substantiate the assessment.*

*A formal QC report should be included in the report. This report will summarize the data validation and will include the results of pertinent laboratory and field QC checks. The individual elements of the QC report should include:*

- o *Listing of actual and field QC samples;*





- o *Listings of the sample digestion groups and digestion-specific QC checks as prepared by the laboratory;*
- o *A summary of all of the problems discovered during the validation and of all corrective actions and the final disposition of the corrective actions;*
- o *A summary of all rejected results requiring reanalysis;*
- o *Summary tables of all field QC checks; and*
- o *Summary of all failings to meet Level A/B criteria.*

*The report will include a discussion of overall precision and accuracy in light of the project data quality objectives, data completeness in terms of percentages of accepted and of non-flagged data, ability of the data to meet all the criteria for Level B, and recommendations for improvements either in the overall QC program or in specific field, field laboratory, or analytical laboratory procedures. It is intended that the QC summary report will serve both as an overview of data quality and as a guide to any future, independent data validation efforts.*

Response: All data qualifiers added during the data evaluation and validation process were made using guidance described in Laboratory Data Validation: Functional Guidelines for Evaluating Inorganics Analyses (U.S. EPA 1988).

Approximately 30 Data Evaluation/Validation/Reduction and QA Statement documents were prepared in support of this RI. These documents along with all raw laboratory data are retained at the CH2M HILL (Helena) offices and are part of the Administrative Record. Each document contains the information listed below.

- o Text describing sampling event(s), sample matrix, Case Number(s), analytes and analytical laboratory. The text also describes results of data evaluation and validation. Analytical and other technical problems are discussed by sample digestion group (SDG), sample number, problem and analytes affected.
- o The impacts of problems encountered on the PARCC parameter are presented.
- o Summary tables of quality assurance statements quantifying the accuracy, precision, completeness and representativeness of each analytical parameter of interest are exhibited.
- o Listing of all field and laboratory QC samples and data used to calculate QA statements are provided.





- o Statistical analysis of QC data are presented.
- o Region VIII Summaries of CLP Data Quality Assurance Reviews arranged by SDG for RAS as well as SAS data are presented. These summaries include discussion of all problems found during validation, corrective actions, use of data qualifiers added by the data reviewers, and rationale for any rejected data.
- o The sample identification matrix form(s) generated during the sampling process are presented. These forms display information relating to sampling locations, types of samples (natural, replicates, field blanks, field standards), matrix, SMO number, EPA tag number, sampling container, date and time sampled, preservation method(s), analyses requested, analytical laboratory, chain-of-custody number, airbill number(s), date shipped to laboratory and other pertinent information.

These Data Evaluation/Validation/Reduction and QA statement documents address all significant QA/QC protocols as outlined in the project documents including the Work Plan and both parts (QAPP and FSP) of the SAP. Data Quality Objectives identified in the project QAPP can be assessed using these documents. Accuracy, precision and completeness targets were outlined in detail in the QAPP. Summary tables provide actual quantification of these three parameters.

2. *All tables. The entries labeled "% of Data" under the ACCURACY and PRECISION heading are not defined. There is insufficient information correlating the summary statistics and the assessment flags assigned to the data. The rationale for including any qualified data in the category "valid" needs to be explained in detail.*

Response: The entries labeled "% of Data" under ACCURACY and PRECISION relate to the completeness of the data used to calculate each statement. The completeness of the accuracy data is that percentage of the total number of sample results that remain after statistical outliers are identified (if any) and/or other results that were not used to calculate accuracy (%R value not used because the sample value was greater than 4x the spiking level). For example, if 4 out of 5 results were used to calculate accuracy based on laboratory spike results, the "% of Data" would be 80%. The excluded result may not have been used because it was a statistical outlier or the sample value exceeded the spike level by a factor of 4. The "% of Data" for the precision statement is calculated in a similar way. Some data used to calculate precision may have been set aside because they were outliers or because one or both values of the pair were less than the IDL. These statistical methods are found in the QAPP document.



Qualifiers added to data were done so upon completion of technical assessment of the data packages using the protocols found in the Functional Guidelines documents and EPA Region VIII Data Quality Assessment Reviews. Justifications for adding qualifiers are found in the DQAR packages. All data except for those rejected (R qualifier) are valid. The EPA Office of Solid Waste and Emergency Response in a memorandum prepared by the Analytical Operations Branch (H. M. Fribush, September 29, 1989) states that "J" qualified CLP data represent data of good quality and reasonable confidence, and is thus suitable for decision-making in Superfund". When the Warm Springs Ponds Phase II RI was conducted there was no policy which stated that "J" qualified data should only be used for screening purposes. The Work Plan, Field Sampling Plan, and the Quality Assurance Plan developed for these investigations were written using the current guidance at that time and reflect that policy. All data are of known quality, i.e. the accuracy and precision have been quantified at the 90% confidence level. An assessment of these data in terms of the Data Quality Objectives should be the determinative factor as to whether the data can be used for decision-making.

3. *Summary QA statements are missing for 2 major cations and 8 metals in Table 6-1A.*

Response: Summary QA statements for these parameters were not prepared and, hence, were not included in the data summary report. Such tables will be prepared using data contained in the QA reports made part of the project administrative record if such information is needed.

4. *There is insufficient information to differentiate the data in Table 6-4A from the data in Table 6-4C. The title of Table 6-4C should be revised to indicate where the Soils/Tailings samples were collected.*

Response: Table 6-4C represents soils and tailings samples collected within the operable unit exclusive of those collected along the Mill-Willow Bypass. The data are presented separately because soils and tailings samples were collected during two separate sampling episodes which resulted in two separate sample shipments.

## 6.5 QUALITY CONTROL OF FIELD MEASUREMENTS

No Comments.





## 7.0 REFERENCES

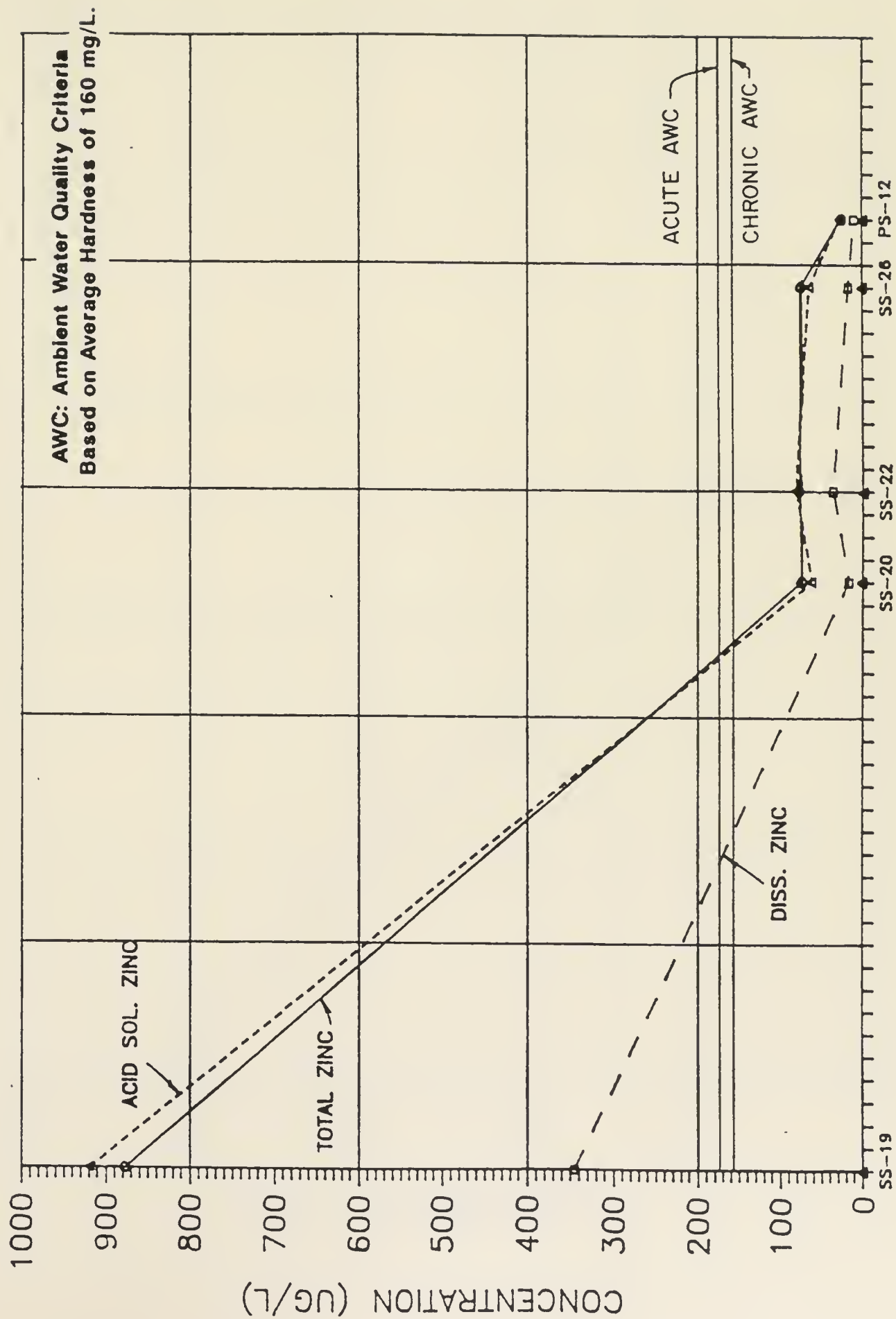
No Comments.



**ATTACHMENT A**



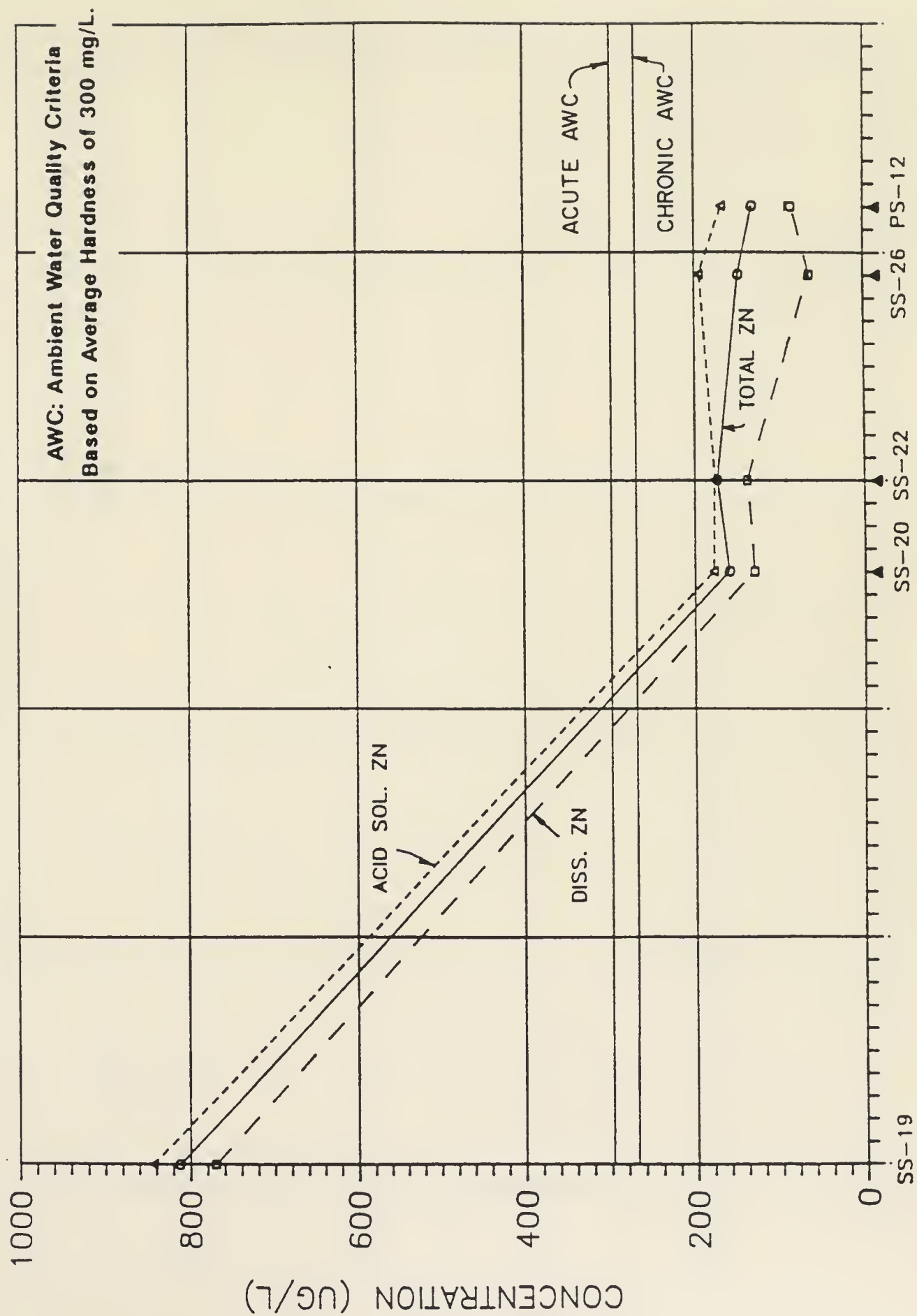
**FIGURE 2-13** AVERAGE ZINC CONCENTRATIONS; SS-19 TO PS-12  
SILVER BOW CREEK CERCLA; PHASE II REMEDIAL INVESTIGATION  
SEPT., 1987





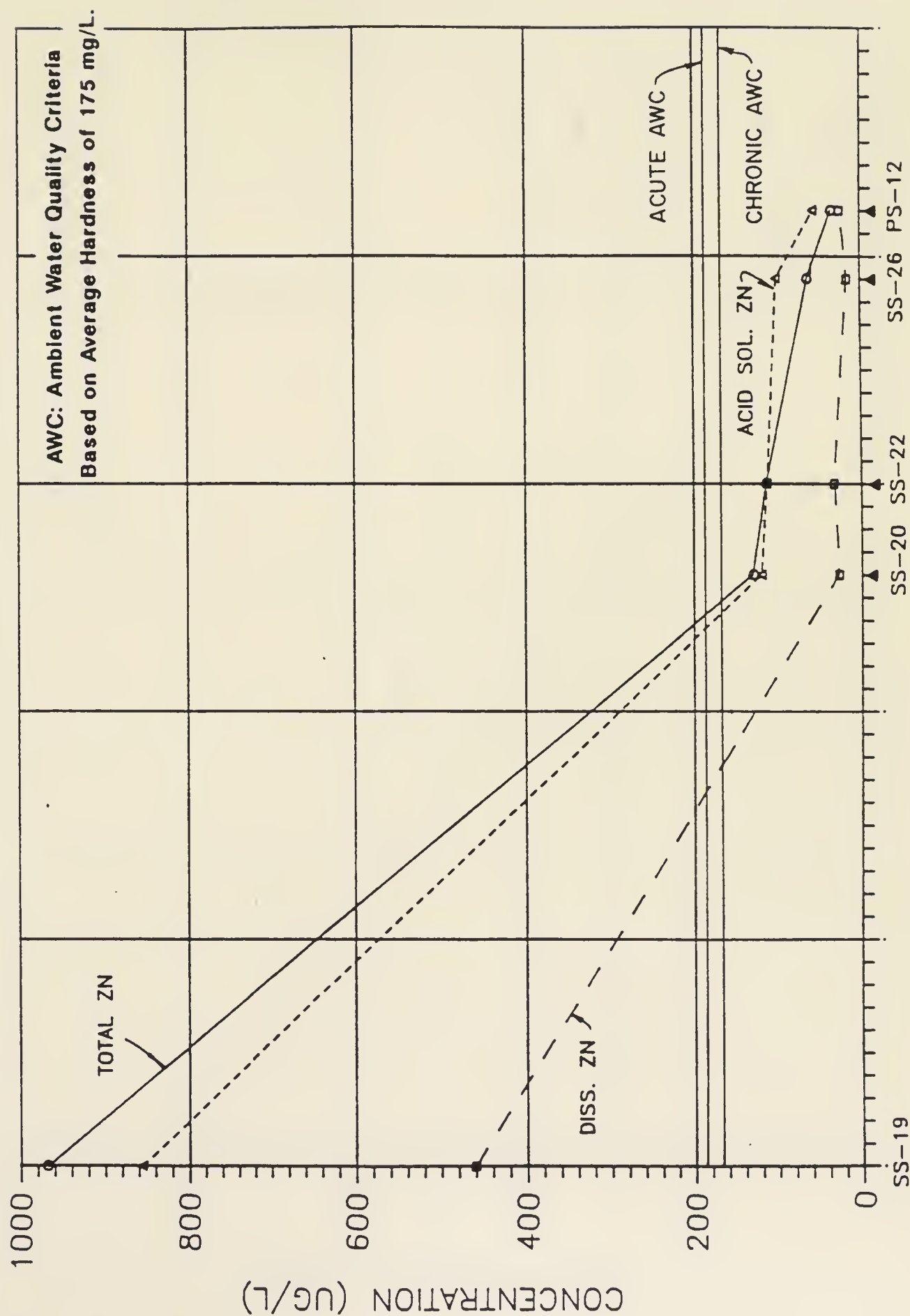


**FIGURE 2-14** AVERAGE ZINC CONCENTRATIONS; SS-19 TO PS-12  
SILVER BOW CREEK CERCLA; PHASE II REMEDIAL INVESTIGATION  
JANUARY, 1988





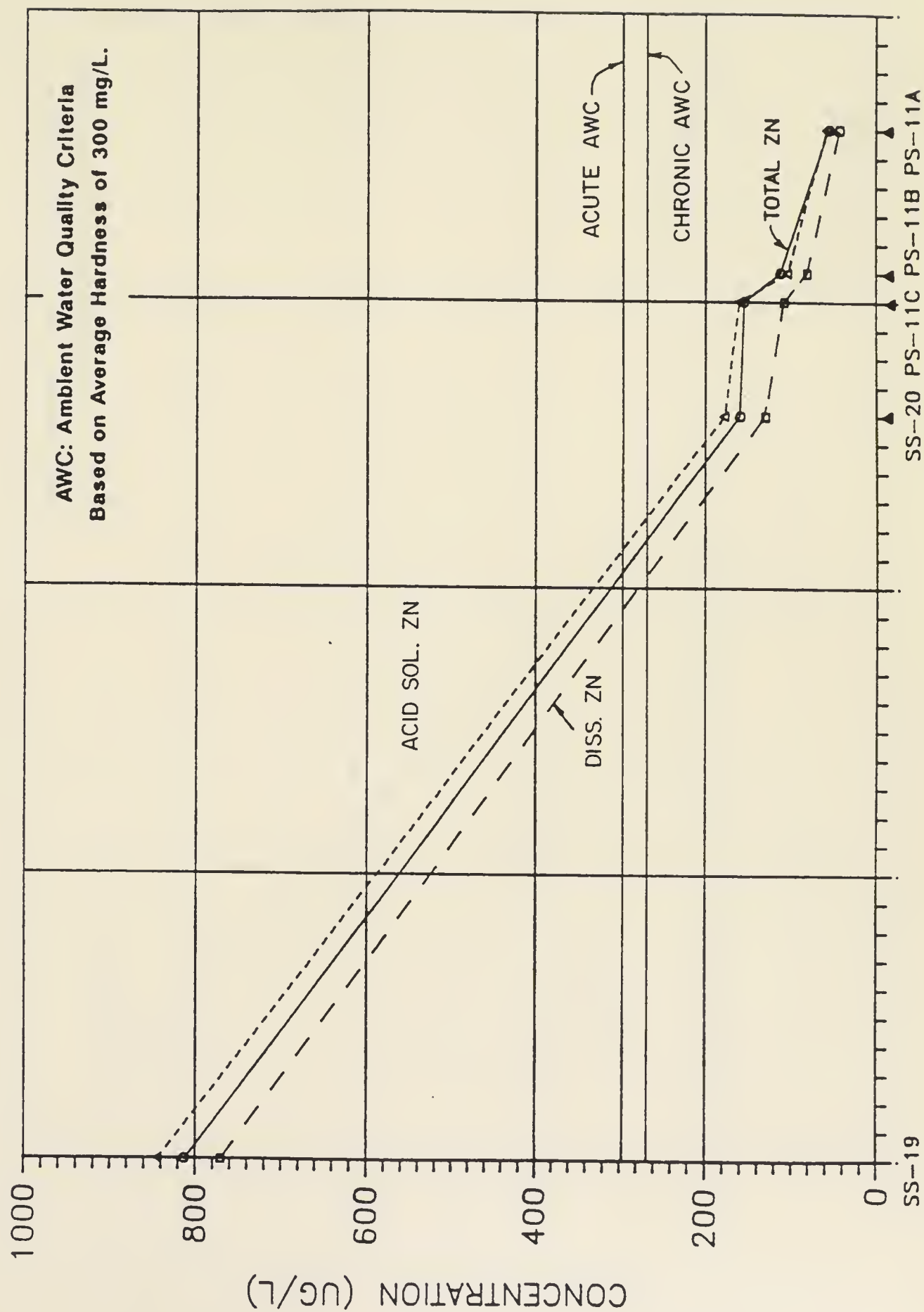
**FIGURE 2-15** AVERAGE ZINC CONCENTRATIONS; SS-19 TO PS-12  
SILVER BOW CREEK CERCLA; PHASE II REMEDIAL INVESTIGATION  
APRIL, 1988





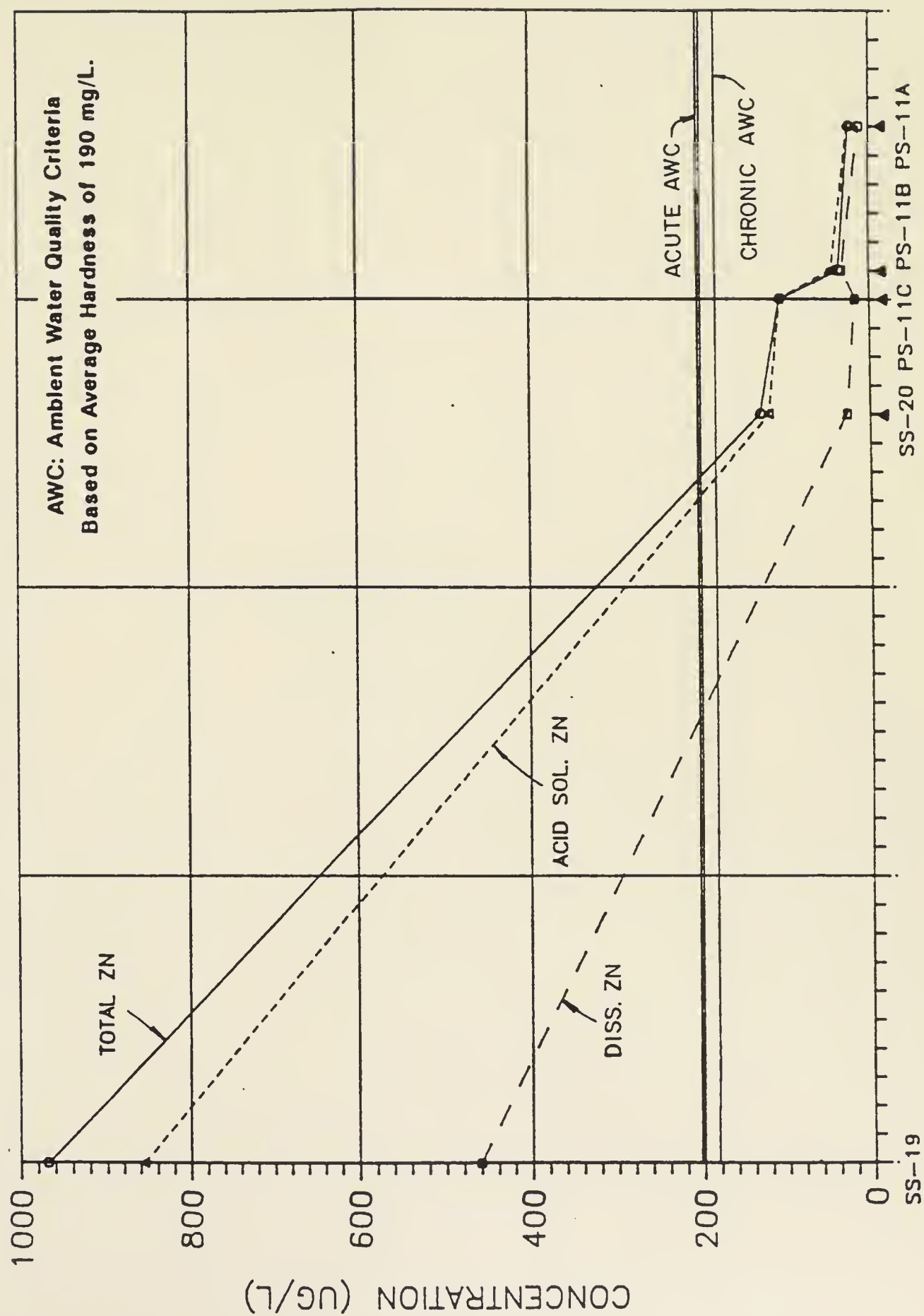


**FIGURE 2-18** AVERAGE ZINC CONCENTRATIONS; SS-19 TO PS-11A  
SILVER BOW CREEK CERCLA; PHASE II REMEDIAL INVESTIGATION  
JANUARY, 1988





**FIGURE 2-19** AVERAGE ZINC CONCENTRATIONS; SS-19 TO PS-11A  
SILVER BOW CREEK CERCLA; PHASE II REMEDIAL INVESTIGATION  
APRIL, 1988





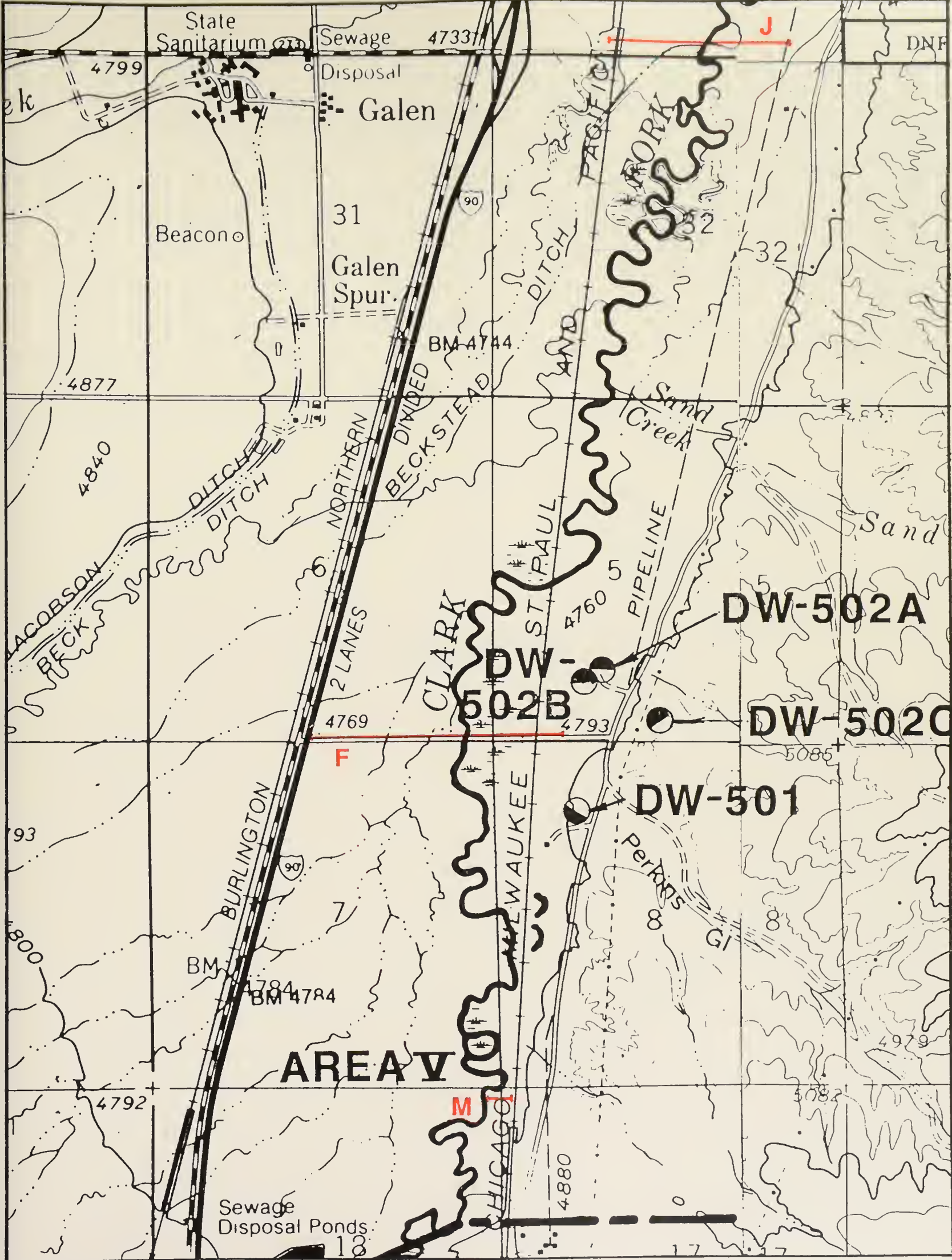
**ATTACHMENT B**





**ATTACHMENT C**





WARM SPRINGS PONDS OPERABLE UNIT  
Phase II Remedial Investigation

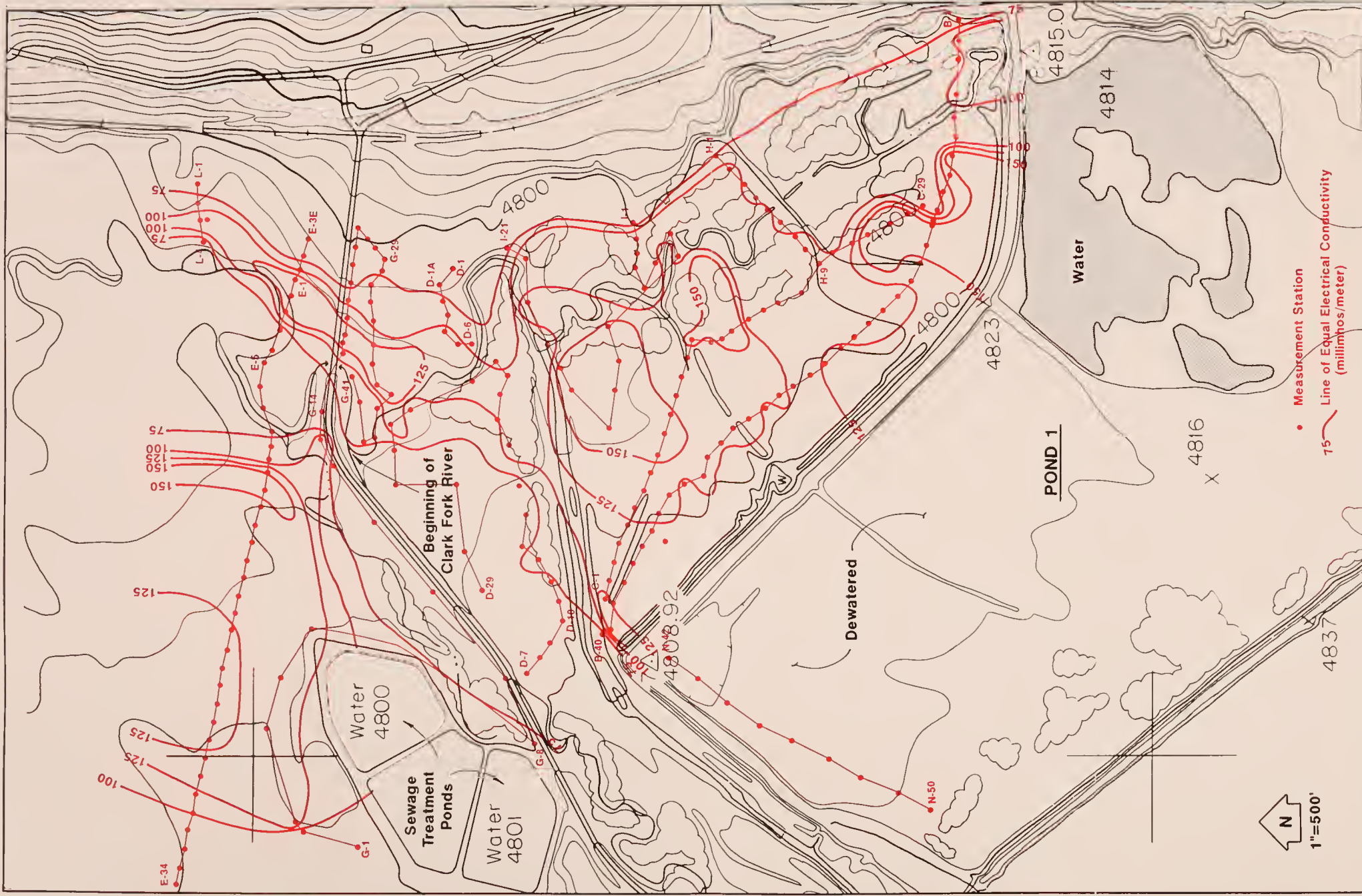
LOCATION OF EM TRANSECTS J,F and M





**ATTACHMENT D**





**WARM SPRINGS PONDS OPERABLE UNIT**  
Phase II Remedial Investigation

**ELECTROMAGNETIC ISOLINE MAP**  
OF THE AREA BELOW POND 1



## WELL COMPLETION LOG

State: Montana County: Deer Lodge Project: SBC CERCLA Hole Name  
or Number: WSP-PW-01

Legal Location: T 4N R 10W Sec 18 Tract DCD Descriptive Location: Below Pond 1 dike, 200 feet south of WSP-GW-19

Recorded Hole Started: Hole Completed:  
By: BG Time: 1230 Date: 02-09-88 Time: 1715 Date: 02-09-88 Driller: Dan O'Keefe/O'Keefe Drilling

Drill Method: Cable Tool Drilling Fluids Used: None Pilot Hole Diameter: 6 in. Reamed Hole Diameter: N/A

Total Depth Drilled: 23 ft. Total Depth Reamed: N/A Total Depth Cased Below G.S.: 22.5 ft. Diameter and Type of Casing: 6" nominal, flush threaded, type 304 stainless steel

Weight or Gage of Casing: Sch 40 Interval Perforated or Screened Below G.S.: 5.5-20.5 ft. Target Aquifer: Qal Packer Type and Depth Below G.S.: K, 5-5.5 ft.

DURING INSTALLATION WAS:	YES	NO	Method Perforated or Screened
Well Developed?	<u>X</u>	<u>      </u>	<u>      </u> No casing in hole
Well Test Pumped?	<u>X</u>	<u>      </u>	<u>      </u> Open bottom
Water Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with Mill's Knife
Material Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with a torch
E-Logs?	<u>      </u>	<u>X</u>	<u>      </u> Screened by pulling casing
			<u>      </u> Field saw cut
			<u>X</u> Mechanical slots <u>0.10</u> (size)
			<u>      </u> Other (specify) <u>      </u>

Static Water Level  
Below Measuring Point: 4.24 Date/Time Measured: 4-22-88/NA

Measuring Point Description/Elevation: Top of Steel, N. Side/4801.17 MP Height Above (+/-) or Below G.S.:       

Well Annulus Completion Description: 0-6 ft., 6 in. steel casing; 0-5 ft., 5 in. steel casing; 5-5.5 ft., k-packer section; 5.5-20.5 ft., screened interval; 20.5-22.5 ft., 5 in. steel casing with bottom cap for sump; well protector with lock at surface.

Well Development Description: Pumped for approximately 45 minutes at +50 GPM, let recover for approximately 30 minutes; surged several times; pumped for approximately 15 minutes until water cleared; let recover for approximately 20 minutes; pumped for 15 minutes until water cleared, then pumped for an additional 30 minutes.

Remarks: Production well.





DRILLING AND LITHOLOGIC LOG

WSP-PW-01 (continued)

(Depth Below G.S.)		
<u>From</u>	<u>To</u>	<u>DRILLING LOG      Geological, Drilling, and Water Conditions and Sampling</u>
0	4	Loam, water added.
4	13	Gravel; small to medium, sand matrix, moderately well sorted. Producing >50 gpm @ 13 to 17 feet.
17	23	Silt; brown, occasional sand; fairly tight; additional water added.



## WELL COMPLETION LOG

State: Montana County: Deer Lodge Project: SBC CERCLA Hole Name  
or Number: WSP-QW-01

Legal Location: T 4N R 10W Sec 18 Tract DCD Descriptive Location: Below Pond 1 dike, 200 feet south of WSP-GW-19

Recorded Hole Started: Hole Completed:  
By: BG Time: 1515 Date: 01-21-88 Time: 1500 Date: 01-22-88 Driller: Dan O'Keefe/O'Keefe Drilling

Drill Method: Cable Tool Drilling Fluids Used: None Pilot Hole Diameter: 6 in. Reamed Hole Diameter: 7.5 in.

Total Depth Drilled: 20 ft. Total Depth Reamed: 20 ft. Total Depth Cased Below G.S.: 19 ft. Diameter and 1 in. flush Type of Casing: threaded PVC

Weight or Gage of Casing: Sch 40 Interval Perforated or Screened Below G.S.: 0-19 ft. Target Aquifer: Qal Packer Type and Depth Below G.S.: N/A

DURING INSTALLATION WAS:	YES	NO	Method Perforated or Screened
Well Developed?	<u>      </u>	<u>X</u>	<u>      </u> No casing in hole
Well Test Pumped?	<u>      </u>	<u>X</u>	<u>X</u> Open bottom
Water Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with Mill's Knife
Material Samples Taken?	<u>X</u>	<u>      </u>	<u>      </u> Slotted with a torch
E-Logs?	<u>      </u>	<u>X</u>	<u>      </u> Screened by pulling casing
			<u>X</u> Field saw cut
			<u>      </u> Mechanical slots <u>      </u> (size)
			<u>      </u> Other (specify) <u>      </u>

Static Water Level  
Below Measuring Point: 3.06 Date/Time Measured: 4-22-88

Measuring Point Description/Elevation: Top of plastic, N. Side/4799.90 MP Height Above (+/-) or Below G.S.:       

Well Annulus Completion Description: 0-19 ft. minus 3/4 in. washed gravel.

Well Development Description:       

Remarks: Well installed as an observation well for aquifer test at WSP-PW-01.





DRILLING AND LITHOLOGIC LOG

WSP-OW-01 (continued)

(Depth Below G.S.)  
From            To

DRILLING LOG    Geological, Drilling, and Water Conditions and Sampling

0	3	Loam; dark brown; water added.
3	17.5	Sand and gravel; moderately well sorted; producing > 5 gpm.
17.5	19	Silt; brown; slightly clayey; added water.



## WELL COMPLETION LOG

State: Montana County: Deer Lodge Project: SBC CERCLA Hole Name  
or Number: WSP-OW-02

Legal Location: T 4N R 10W Sec 18 Tract DCD Descriptive Location: Below Pond 1 dike, 100 feet south of WSP-GW-19

Recorded Hole Started: Hole Completed:  
By: DO Time: 0830 Date: 01-25-88 Time: 1130 Date: 01-25-88 Driller: Dan O'Keefe/O'Keefe Drilling

Drill Method: Cable Tool Drilling Fluids Used: None Pilot Hole Diameter: 6 in. Reamed Hole Diameter: 7 in.

Total Depth Drilled: 20 ft. Total Depth Reamed: 20 ft. Total Depth Cased Below G.S.: 19 ft. Diameter and Type of Casing: 1 in. flush threaded PVC

Weight or Gage of Casing: Sch 40 Interval Perforated or Screened Below G.S.: 0-19 ft. Target Aquifer: Qal Packer Type and Depth Below G.S.: N/A

DURING INSTALLATION WAS:	YES	NO	Method Perforated or Screened
Well Developed?	<u>      </u>	<u>X</u>	<u>      </u> No casing in hole
Well Test Pumped?	<u>      </u>	<u>X</u>	<u>X</u> Open bottom
Water Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with Mill's Knife
Material Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with a torch
E-Logs?	<u>      </u>	<u>X</u>	<u>      </u> Screened by pulling casing
			<u>X</u> Field saw cut
			<u>      </u> Mechanical slots <u>      </u> (size)
			<u>      </u> Other (specify) <u>      </u>

Static Water Level  
Below Measuring Point: 3.66 Date/Time Measured: 4-22-88/NA

Measuring Point Description/Elevation: Top of PVC/4799.97 MP Height Above (+/-) or Below G.S.: NA

Well Annulus Completion Description: 0-19 ft. minus 3/4 in. washed gravel.

Well Development Description:       

Remarks: Well installed as an observation well for aquifer test at WSP-PW-01.



DRILLING AND LITHOLOGIC LOG

WSP-OW-02 (continued)

(Depth Below G.S.)

<u>From</u>	<u>To</u>	<u>DRILLING LOG</u> <u>Geological, Drilling, and Water Conditions and Sampling</u>
0	4	Loam; water added for drilling fluid.
4	17	Gravel and sand; moderately well sorted; producing > 5 gpm.
17	19	Silt; brown; producing little water.





## WELL COMPLETION LOG

Hole Name  
 State: Montana County: Deer Lodge Project: SBC CERCLA or Number: WSP-OW-03 (S&D) (Dual Completion)

Legal Descriptive Below Pond 1 dike, 200 feet south of WSP-GW-19,  
 Location: T 4N R 10W Sec 18 Tract DCD Location: 12 feet west of production well location

Recorded Hole Started: Hole Completed:  
 By: BG Time: 1200 Date: 01-25-88 Time: 1230 Date: 02-08-88 Driller: Dan O'Keefe/O'Keefe Drilling

Drill Drilling Pilot Hole Reamed Hole  
 Method: Cable Tool Fluids Used: None Diameter: 6 in. Diameter: N/A

Total Depth Total Depth Total Depth Diameter and  
 Drilled: 33 ft. Reamed: N/A Cased Below G.S.: 32 ft. Type of Casing: 2" flush threaded PVC

Weight or Interval Perforated 26.5-31.5 ft. Target Packer Type and  
 Gage of Casing: Sch 40 or Screened Below G.S.: 5-17 ft. Aquifer: Qal Depth Below G.S.: N/A

DURING INSTALLATION WAS:	YES	NO	Method Perforated or Screened
Well Developed?	<u>      </u>	<u>X</u>	<u>      </u> No casing in hole
Well Test Pumped?	<u>      </u>	<u>X</u>	<u>      </u> Open bottom
Water Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with Mill's Knife
Material Samples Taken?	<u>      </u>	<u>X</u>	<u>      </u> Slotted with a torch
E-Logs?	<u>      </u>	<u>X</u>	<u>      </u> Screened by pulling casing
			<u>X</u> Field saw cut
			<u>X</u> Mechanical slots <u>.030</u> (size)
			<u>      </u> Other (specify) <u>      </u>

Note: Mechanical slots from 7 to 17 feet  
 Field saw cuts from 5 to 7 feet

Static Water Level 3.42 (Shallow)  
 Below Measuring Point: 2.74 (Deep) Date/Time Measured: 4-22-88

Measuring Point MP Height Above (+/-)  
 Description/Elevation: Top of steel, N. side/4800.38 or Below G.S.: NA

Well Annulus  
 Completion Description: 1.5-3.5 ft., volclay grout; 3.5-4.0 ft., volclay pellets; 4.0-18 ft., 10-20 sand;  
18-19 ft., volclay pellets; 19-23 ft., volclay grout; 23-26 ft., volclay pellets; 26-32 ft., 10-20 sand;  
32-32.5 ft., volclay pellets. Concrete grout, steel well protector with lock at surface.

Well Development Description:       

Remarks: Note: This well completed for use as a monitoring well if needed.



## DRILLING AND LITHOLOGIC LOG

WSP-OW-03(S&D) (continued)

(Depth Below G.S.)		<u>DRILLING LOG</u>	<u>Geological, Drilling, and Water Conditions and Sampling</u>
<u>From</u>	<u>To</u>		
0	4	Loam; water added for drilling fluid.	
4	17	Gravels; producing water from 13 to 17 feet.	
17	27	Silt; brown; water added for drilling fluid.	
27	31	Sand; medium-fine; interbedded with silt; producing water. First producing zone encountered below gravels.	
31	33	Silt; brown.	





**ATTACHMENT E**



06/26/90

## STATIC

SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	SMO NUMBER	SAMPLE METHOD	WATER LEVEL		TEMPERATURE (deg. F)	pH (s.u.)	SPECIFIC CONDUCTANCE (umhos/cm)	DISSOLVED OXYGEN (mg/L)
						(-FT)	(-FT)				
WSP-GW-01	N	05/19/88	1045	3778H-144	BAILER	3.35		10.5	7.7	374	8.6
WSP-GW-020	N	05/23/88	1520	3778H-171	BAILER	2.09		11.0	6.6	1340	7.2
WSP-GW-02S	N	05/23/88	1600	3778H-172	BAILER	4.64		9.0	6.7	2740	4.3
WSP-GW-03D	N	05/23/88	1130	3778H-167	BAILER	5.15		11.5	7.2	1980	3.8
WSP-GW-03S	N	05/23/88	1215	3778H-168	BAILER	4.76		11.0	7.2	2110	4.2
WSP-GW-04	BB	05/24/88	1630	3778H-186							
WSP-GW-04	N	05/24/88	1700	3778H-187	BAILER	6.78		12.0	7.3	963	5.0
WSP-GW-05	N	05/24/88	1545	3778H-185	BAILER	6.25		9.5	7.2	1970	4.9
WSP-GW-060	N	05/19/88	1200	3778H-145	BAILER	3.20		8.5	7.8	373	10.2
WSP-GW-06S	N	05/19/88	0945	3778H-143	BAILER	4.32		6.5	7.2	445	5.4
WSP-GW-070	N	05/19/88	1635	3778H-149	BAILER	4.97		9.5	7.2	860	10.2
WSP-GW-070	BB	05/19/88	1640	3778H-150							
WSP-GW-07D	BFS	05/19/88	1720	3778H-151							
WSP-GW-07S	N	05/19/88	1730	3778H-152	BAILER	5.50		8.0	7.8	517	2.4
WSP-GW-07S	R	05/19/88	1800	3778H-153	BAILER			8.0	7.8	522	3.1
WSP-GW-07S	WB	05/19/88	1815	3778H-154	BAILER			18.0	4.6	23	8.1
WSP-GW-08D	N	05/19/88	1420	3778H-147	BAILER	4.85		9.0	7.4	613	5.0
WSP-GW-08S	N	05/19/88	1515	3778H-148	BAILER	4.81		9.0	7.3	1150	3.8
WSP-GW-09	N	05/19/88	1315	3778H-146	BAILER	19.46		10.5	7.4	540	9.4
WSP-GW-100	N	05/20/88	1150	3778H-157	BAILER	9.82		9.0	7.4	1800	5.6
WSP-GW-10S	N	05/20/88	1230	3778H-158	BAILER	9.92		8.0	7.2	1220	2.2
WSP-GW-110	N	05/20/88	1410	3778H-159	BAILER	4.97		8.0	6.8	1650	3.8
WSP-GW-110	R	05/20/88	1420	3778H-160	BAILER			10.0	6.9	1700	4.5
WSP-GW-11S	N	05/20/88	1515	3778H-161	BAILER	4.30		7.0	7.0	2000	3.3
WSP-GW-120	N	05/24/88	1410	3778H-182	BAILER	4.62		9.0	7.4	505	4.6
WSP-GW-120	R	05/24/88	1420	3778H-183	BAILER			10.0	7.4	514	4.5
WSP-GW-12S	N	05/24/88	1445	3778H-184	BAILER	3.70		9.0	7.0	1350	4.0
WSP-GW-13D	N	05/23/88	1320	3778H-169	BAILER	4.35		10.0	6.9	1630	6.3
WSP-GW-13S	N	05/23/88	1400	3778H-170	BAILER	5.65		9.0	6.7	2470	4.7
WSP-GW-140	N	05/23/88	1730	3778H-173	BAILER	4.59		11.0	7.3	1160	4.8
WSP-GW-14D	R	05/23/88	1745	3778H-174	BAILER			10.0	7.2	1200	4.7
WSP-GW-140	BB	05/23/88	1800	3778H-175							

NOTES: 1) Units are ug/L unless otherwise noted.

2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.

3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimate or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits.

4) Blank values indicate parameters not determined or not reported.



DISSOLVED METALS:

SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	Aluminum	Cadmium	Calcium	Copper	Iron	Lead	Magnesium	Manganese	Zinc
WSP-GW-01	N	05/19/88	1045	35.0 U	5.0 U	40700	6.4 B	56.0 U	2.0 U	7350	7.0 U	20.0 J
WSP-GW-02D	N	05/23/88	1520	35.0 U	7.3	214000	6.0 U	409	2.0 UW	47600	4460	18.1 B J
WSP-GW-02S	N	05/23/88	1600	35.0 U	10.7	444000	6.0 U	76500	20.0 UW	163000	26400	51.7
WSP-GW-03D	N	05/23/88	1130	35.0 U	7.2	417000	6.0 U	56.0 U	20.0 UW	91900	97.7	16.1 B J
WSP-GW-03S	N	05/23/88	1215	35.0 U	8.3	465000	6.0 U	163	20.0 UW	99000	335	16.3 B J
WSP-GW-04	BB	05/24/88	1630	35.0 U	5.0 U	186 B	6.0 U	56.0 U	2.0 U	96.8 B	7.0 U	2.9 B
WSP-GW-04	N	05/24/88	1700	35.0 U	5.0 U	171000	6.0 U	56.0 U	2.0 UW	38000	7.0 U	27.2
WSP-GW-05	N	05/24/88	1545	35.0 U	12.7	398000	6.0 U	1020	2.0 UW	87200	6990	149
WSP-GW-06D	N	05/19/88	1200	35.0 U	5.0 U	39700	6.1 B	56.0 U	2.0 U	7540	7.0 U	4.7 B J
WSP-GW-06S	N	05/19/88	0945	35.0 U	5.0 U	47100	9.7 B	56.0 U	2.0 U	10500	7.0 U	240
WSP-GW-07D	N	05/19/88	1635	35.0 U	5.2	107000	6.0 U	56.0 U	2.0 U	35900	7.0 U	9.3 B J
WSP-GW-07D	BB	05/19/88	1640	35.0 U	5.0 U	240 B J	6.0 U	56.0 U	2.0 U	70.0 U	7.0 U	2.6 B
WSP-GW-07D	BFS	05/19/88	1720	228	172	65600	267	271	121	27200	200	362
WSP-GW-07S	N	05/19/88	1730	35.0 U	5.0 U	73800	6.0 U	56.0 U	2.0 UW	10600	114	22.5 J
WSP-GW-07S	R	05/19/88	1800	35.0 U	5.0 U	74500	6.0 U	56.0 U	2.0 UW	10700	116	32.3
WSP-GW-07S	WB	05/19/88	1815	35.0 U	5.0 U	193 B J	6.0 U	56.0 U	2.0 U	70.0 U	7.0 U	5.3 B
WSP-GW-08D	N	05/19/88	1420	35.0 U	5.0 U	90100	7.1 B	56.0 U	2.0 U	23400	7.0 U	6.2 B J
WSP-GW-08S	N	05/19/88	1515	35.0 U	5.0 U	186000	6.0 U	56.0 U	20.0 U	52600	45.0	12.7 B J
WSP-GW-09	N	05/19/88	1315	35.0 U	5.0 U	52600	8.4 B	56.0 U	2.0 UW	13600	7.1 B	21.2 J
WSP-GW-10D	N	05/20/88	1150	35.0 U	5.9	364000	6.0 U	56.0 U	20.0 UW	74000	2150	41.7 J
WSP-GW-10S	N	05/20/88	1230	35.0 U	5.0 U	231000	6.0 U	2530	20.0 UW	22600	10800	330
WSP-GW-11D	N	05/20/88	1410	35.0 U	5.0 U	278000	8.7 B	2630	20.0 UW	61200	15700	104
WSP-GW-11D	R	05/20/88	1420	35.0 U	5.0 U	277000	6.0 U	1630	20.0 UW	61700	15900	64.8
WSP-GW-11S	N	05/20/88	1515	58.9 B	5.0 U	327000	10.0 B	52500	20.0 UW	50400	13200	1090
WSP-GW-12D	N	05/24/88	1410	35.0 U	5.0 U	84800	6.0 U	56.0 U	2.0 U	20400	35.2	12.2 B J
WSP-GW-12D	R	05/24/88	1420	35.0 U	5.0 U	84400	6.0 U	56.0 U	2.0 UW	20500	22.4	8.0 B
WSP-GW-12S	N	05/24/88	1445	35.0 U	6.8	244000	15.9 B	56.0 U	2.0 UW	52900	8180	253
WSP-GW-13D	N	05/23/88	1320	35.0 U	5.0 U	292000	6.0 U	56.0 U	2.0 UW	66300	13.2 B	10.6 B J
WSP-GW-13S	N	05/23/88	1400	35.0 U	11.5	465000	6.0 U	31600	20.0 UW	134000	16200	29.9 J
WSP-GW-14D	N	05/23/88	1730	35.0 U	5.0 U	186000	6.0 U	56.0 U	2.0 UW	41300	1210	10.1 B J
WSP-GW-14D	R	05/23/88	1745	35.0 U	6.5	185000	6.0 U	56.0 U	2.0 UW	40700	1240	17.1 B
WSP-GW-14D	BB	05/23/88	1800	35.0 U	5.0 U	202 B	6.0 U	56.0 U	2.0 U	70.0 U	7.0 U	2.0 U

NOTES: 1) Units are ug/L unless otherwise noted.  
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.  
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits.  
4) Blank values indicate parameters not determined or not reported.





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SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	MINERALS:			Nitrate & Nitrite (mg/l)	Fluoride (mg/l)	Chloride (mg/l)	OTHER PARAMETERS: (mg/l)	
				Sulfate (mg/l)	Sodium	Potassium				Alkalinity	Total Hardness
WSP-GW-01	N	05/19/88	1045	37300	3670 B		26.0 J		0.85 J	11.3 J	162
WSP-GW-02D	N	05/23/88	1520	34900	4990 B		554 J		0.33 J	10.6 J	160 J
WSP-GW-02S	N	05/23/88	1600	71600	12300		1620 J		2.5 J	21.6 J	207 J
WSP-GW-030	N	05/23/88	1130	24700	7160		1150 J		0.51 J	9.3 J	257 J
WSP-GW-03S	N	05/23/88	1215	27800	7430		1280 J		0.55 J	10.9 J	230 J
WSP-GW-04	BB	05/24/88	1630	2000 U	126 U		<1.0 UJ		<0.10 UJ	<5.0 UJ	<2.0
WSP-GW-04	N	05/24/88	1700	13600	4310 B		398 J		0.50 J	6.2 J	205
WSP-GW-05	N	05/24/88	1545	30100	7980		1180 J		1.2 J	11.2 J	238
WSP-GW-060	N	05/19/88	1200	38000	3550 B		22.6 J		0.78 J	11.2 J	144
WSP-GW-06S	N	05/19/88	0945	47700	3690		63.3 J		1.0 J	14.4 J	170
WSP-GW-070	N	05/19/88	1635	21100	9580		200 J		0.90 J	10.1 J	193
WSP-GW-070	BB	05/19/88	1640	2000 U	126 U		1.0 U UJ		0.10 U UJ	5.0 U UJ	2.0 U
WSP-GW-070	BFS	05/19/88	1720	244000	142000		140 J		8.0 J	232 J	185
WSP-GW-07S	N	05/19/88	1730	19500	6860		142 J		1.8 J	10.8 J	93.6
WSP-GW-07S	R	05/19/88	1800	19600	6960		139 J		1.6 J	10.7 J	93.6
WSP-GW-07S	WB	05/19/88	1815	2000 U	146 B		1.0 U UJ		0.10 U UJ	5.0 U UJ	2.0 U
WSP-GW-080	N	05/19/88	1420	10500	3430 B		101 J		0.54 J	5.0 U UJ	177
WSP-GW-08S	N	05/19/88	1515	13200	6730		461 J		0.72 J	5.5 J	222
WSP-GW-09	N	05/19/88	1315	42700	4300 B		71.2 J		0.90 J	22.6 J	154
WSP-GW-100	N	05/20/88	1150	24300	7680		1050 J		0.54 J	10.7 J	224
WSP-GW-10S	N	05/20/88	1230	32200	11700		470 J		5.7 J	9.8 J	242
WSP-GW-110	N	05/20/88	1410	23500	13000		687 J		1.3 J	10.0 J	193
WSP-GW-110	R	05/20/88	1420	23200	11200		660 J		1.2 J	10.2 J	211
WSP-GW-11S	N	05/20/88	1515	28700	15800		1006 J		3.4 J	11.8 J	84.0
WSP-GW-120	N	05/24/88	1410	13000	4050 B		106 J		0.68 J	<5 UJ	185 J
WSP-GW-120	R	05/24/88	1420	13000	3880 B		101 J		0.60 J	<5.0 UJ	193
WSP-GW-12S	N	05/24/88	1445	22700	5840		689 J		2.2 J	7.4 J	207
WSP-GW-130	N	05/23/88	1320	27300	5920		723 J		0.38 J	9.4 J	274 J
WSP-GW-13S	N	05/23/88	1400	36100	11000		1490 J		1.0 J	12.1 J	218 J
WSP-GW-140	N	05/23/88	1730	36600	5570		554 J		0.43 J	9.8 J	119 J
WSP-GW-140	R	05/23/88	1745	35400	5050		565 J		0.43 J	9.4 J	116 J
WSP-GW-140	BB	05/23/88	1800	2000 U	126 U		<1 UJ		<0.1 UJ	<5 UJ	<2 UJ

NOTES: 1) Units are ug/L unless otherwise noted.

2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.

3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, 0 = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RP0, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met. W = post digestion spike for furnace AA was not within control limits.

4) Blank values indicate parameters not determined or not reported.



SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	ARSENIC SPECIATION:			ARSENIC (V)
				TOTAL DISSOLVED ARSENIC	ARSENIC (III)	ARSENIC (V)	
WSP-GW-01	N	05/19/88	1045	2.6 B			
WSP-GW-02D	N	05/23/88	1520	2.0 UW	4.0 UN	4.0 UN	
WSP-GW-02S	N	05/23/88	1600	197	72 N J	165 N J	
WSP-GW-03D	N	05/23/88	1130	2.0 UW			
WSP-GW-03S	N	05/23/88	1215	2.0 UW			
WSP-GW-04	BB	05/24/88	1630	2.0 U			
WSP-GW-04	N	05/24/88	1700	2.0 U			
WSP-GW-05	N	05/24/88	1545	2.0 UW	4.0 UN R	5.2 N R	
WSP-GW-06D	N	05/19/88	1200	3.0 B	4.0 UW R	4.6 N R	
WSP-GW-06S	N	05/19/88	0945	4.9 B	4.0 UN	4.2 N R	
WSP-GW-07D	N	05/19/88	1635	2.0 U			
WSP-GW-07D	BB	05/19/88	1640	2.0 U			
WSP-GW-07D	BFS	05/19/88	1720	58.5			
WSP-GW-07S	N	05/19/88	1730	28.1			
WSP-GW-07S	R	05/19/88	1800	28.2			
WSP-GW-07S	WB	05/19/88	1815	2.0 U			
WSP-GW-08D	N	05/19/88	1420	2.0 U			
WSP-GW-08S	N	05/19/88	1515	2.0 U			
WSP-GW-09	N	05/19/88	1315	6.7 B			
WSP-GW-10D	N	05/20/88	1150	2.0 U			
WSP-GW-10S	N	05/20/88	1230	16.8	4.0 UN R	4.0 UN R	
WSP-GW-11D	N	05/20/88	1410	4.1 B	4.0 UN R	4.0 UN R	
WSP-GW-11D	R	05/20/88	1420	2.8 B	47 SN J	121 SN J	
WSP-GW-11S	N	05/20/88	1515	105			
WSP-GW-12D	N	05/24/88	1410	2.0 U			
WSP-GW-12D	R	05/24/88	1420	2.0 U			
WSP-GW-12S	N	05/24/88	1445	2.0 U			
WSP-GW-13D	N	05/23/88	1320	2.0 UW	23. N	47 N	
WSP-GW-13S	N	05/23/88	1400	61.2 S			
WSP-GW-14D	N	05/23/88	1730	2.0 UW			
WSP-GW-14D	R	05/23/88	1745	2.0 UW			
WSP-GW-14D	BB	05/23/88	1800	2.0 U			

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2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.

3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met. W = post digestion spike for furnace AA was not within control limits.

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06/26/90

SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	SMO NUMBER	SAMPLE METHOD	STATIC WATER		TEMPERATURE (deg. F)	pH (s.u.)	SPECIFIC CONDUCTANCE (umhos/cm)	DISSOLVED OXYGEN (mg/L)
						LEVEL (-FT)	WATER LEVEL (-FT)				
WSP-GW-14S	N	05/23/88	1820	3778H-176	BAILER	4.92		13.0	7.4	848	4.4
WSP-GW-14S	WB	05/23/88	1840	3778H-177				21.0	5.8	18	6.1
WSP-GW-14S	BFS	05/23/88	1900	3778H-178							
WSP-GW-15D	N	05/20/88	0915	3778H-155	BAILER	10.65		9.0	7.1	1420	4.8
WSP-GW-15S	N	05/20/88	1015	3778H-156	BAILER	12.09		7.5	7.6	524	5.9
WSP-GW-16D	N	05/20/88	1615	3778H-162	BAILER	2.12		9.0	7.2	1920	3.3
WSP-GW-16S	N	05/20/88	1700	3778H-163	BAILER	2.73		9.0	7.3	1990	5.7
WSP-GW-16S	WB	05/20/88	1720	3778H-164	BAILER			21.0	6.3	17	7.6
WSP-GW-16S	BB	05/20/88	1730	3778H-165							
WSP-GW-16S	BFS	05/20/88	1740	3778H-166							
WSP-GW-17	N	05/24/88	1230	3778H-181	BAILER	2.74		8.0	7.1	1730	4.3
WSP-GW-18D	N	05/24/88	1745	37784-188	BAILER	6.38		11.0	7.4	771	4.8
WSP-GW-18D	WB	05/24/88	1800	3778H-189	BAILER			25.0	6.3	7	6.5
WSP-GW-18S	N	05/24/88	1840	3778H-190	BAILER	6.47		11.0	7.1	921	5.4
WSP-GW-18S	BFS	05/24/88	1900	3778H-191							
WSP-GW-19D	N	05/24/88	0920	3778H-179	BAILER	3.06		9.0	7.4	1100	5.3
WSP-GW-19S	N	05/24/88	1015	3778H-180	BAILER	3.35		8.0	6.9	1720	4.7

NOTES: 1) Units are ug/L unless otherwise noted.

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3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits.

4) Blank values indicate parameters not determined or not reported.



06/26/90

DISSOLVED METALS:

SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	Aluminum	Cadmium	Calcium	Copper	Iron	Lead	Magnesium	Manganese	Zinc
WSP-GW-14S	N	05/23/88	1820	35.0 U	5.0 U	142000	6.0 U	56.0 U	2.0 UW	23600	352	35.5
WSP-GW-14S	WB	05/23/88	1840	35.0 U	5.0 U	179 B	6.0 U	56.0 U	2.0 U	70.0 U	7.0 U	6.9 B
WSP-GW-14S	BFS	05/23/88	1900	219	186	64.0 U	275	267	2.0 UW	70.0 U	210	383
WSP-GW-150	N	05/20/88	0915	35.0 U	5.0 U	254000	6.0 U	56.0 U	2.0 B	53300	10.2 B	37.1 J
WSP-GW-15S	N	05/20/88	1015	35.0 U	5.0 U	74800	6.0 U	259	2.0 UW	12700	1490	36.1 J
WSP-GW-160	N	05/20/88	1615	35.0 U	5.0 U	386000	6.0 U	70.1 B	20.0 UW	66400	8550	6.3 B J
WSP-GW-16S	N	05/20/88	1700	35.0 U	5.0 U	396000	6.0 U	573	20.0 UW	70300	10100	33.5 J
WSP-GW-16S	WB	05/20/88	1720	35.0 U	5.0 U	284 B	6.0 U	56.0 U	2.0 UW	121 B	7.7 B	10.2 B
WSP-GW-16S	BB	05/20/88	1730	35.0 U	5.0 U	64.0 U	6.0 U	56.0 U	2.0 UW	121 B	7.0 U	3.7 B
WSP-GW-16S	BFS	05/20/88	1740	211	177	64.0 U	275	271	114 S	70.0 U	204	383
WSP-GW-17	N	05/24/88	1230	36.6 B	11.7	386000	6.0 U	2360	2.0 UW	68300	14000	1180
WSP-GW-180	N	05/24/88	1745	35.0 U	5.8	122000	6.0 U	174	2.0 UW	28000	3320	69.2
WSP-GW-180	WB	05/24/88	1800	35.0 U	5.0 U	223 B	6.0 U	56.0 U	2.0 U	70.0 U	7.0 U	5.2 B
WSP-GW-18S	N	05/24/88	1840	35.0 U	10.9	160000	6.0 U	56.0 U	2.0 UW	27300	29.5	18.8 B J
WSP-GW-18S	BFS	05/24/88	1900	221	177	64.0 U	271	252	132	70.0 U	206	373
WSP-GW-190	N	05/24/88	0920	35.0 U	8.4	206000	6.0 U	56.0 U	2.0 UW	46200	82.2	6.2 B J
WSP-GW-19S	N	05/24/88	1015	35.0 U	7.1	342000	6.0 U	8650	2.0 UW	67900	10700	16.6 B J

NOTES: 1) Units are ug/L unless otherwise noted.

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3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits.

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06/26/90

SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	MINERALS:			Nitrate & Nitrite (mg/l)	Fluoride (mg/l)	Chloride (mg/l)	OTHER PARAMETERS: (mg/l)		
				Sulfate (mg/l)	Sodium	Potassium				Total Alkalinity	Total Hardness	
WSP-GW-14S	N	05/23/88	1820	26000	4150 B		325 J		1.9 J	10.1 J	145 J	
WSP-GW-14S	WB	05/23/88	1840	2000 U	168 B		<1 UJ		<0.1 UJ	<5 UJ	<2 UJ	
WSP-GW-14S	BFS	05/23/88	1900	2000 U	126 U		136 J		10.0 J	233 J	176 J	
WSP-GW-15D	N	05/20/88	0915	16000	5810		606 J		0.30 J	9.4 J	191	
WSP-GW-15S	N	05/20/88	1015	22400	5850		128 J		1.8 J	11.2 J	137	
WSP-GW-16D	N	05/20/88	1615	32000	10900		1060 J		1.2 J	10.8 J	236	
WSP-GW-16S	N	05/20/88	1700	31900	13000		1130 J		4.1 J	11.2 J	216	
WSP-GW-16S	WB	05/20/88	1720	2000 U	126 U		<1 UJ		<0.1 UJ	<5 UJ	<2	
WSP-GW-16S	BB	05/20/88	1730	2000 U	126 U		<1 UJ		<0.1 UJ	<5 UJ	<2	
WSP-GW-16S	BFS	05/20/88	1740	2000 U	126 U		131 J		10.0 J	234 J	182	
WSP-GW-17	N	05/24/88	1230	28300	11300		1110 J		5.3 J	11.0 J	205 J	
WSP-GW-18D	N	05/24/88	1745	31500	4340 B		335 J		0.41 J	7.9 J	185	
WSP-GW-18D	WB	05/24/88	1800	2000 U	126 U		<1.0 UJ		<0.10 UJ	<5.0 UJ	<2.0	
WSP-GW-18S	N	05/24/88	1840	17500	3850		420 J		0.60 J	6.6 J	138	
WSP-GW-18S	BFS	05/24/88	1900	2000 U	126 U		154 J		10.0 J	235 J	197	
WSP-GW-19D	N	05/24/88	0920	14700	5040		484 J		0.60 J	6.6 J	230 J	
WSP-GW-19S	N	05/24/88	1015	25000	9190		1030 J		2.15 J	10.8 J	224 J	

NOTES: 1) Units are ug/L unless otherwise noted.

2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.

3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met. W = post digestion spike for furnace AA was not within control limits.

4) Blank values indicate parameters not determined or not reported.





SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	ARSENIC SPECIATION:		
				TOTAL ARSENIC	ARSENIC (III)	ARSENIC (V)
WSP-GW-14S	N	05/23/88	1820	3.6 8W		
WSP-GW-14S	WB	05/23/88	1840	2.0 U		
WSP-GW-14S	BFS	05/23/88	1900	2.0 U		
WSP-GW-150	N	05/20/88	0915	2.0 U		
WSP-GW-15S	N	05/20/88	1015	6.5 8		
WSP-GW-160	N	05/20/88	1615	2.0 UW		
WSP-GW-16S	N	05/20/88	1700	2.0 UW		
WSP-GW-16S	WB	05/20/88	1720	2.0 UW		
WSP-GW-16S	BB	05/20/88	1730	2.0 UW		
WSP-GW-16S	8FS	05/20/88	1740	60.6		
WSP-GW-17	N	05/24/88	1230	2.0 U	4.0 UN R	5.9 N R
WSP-GW-180	N	05/24/88	1745	2.0 UW		
WSP-GW-180	WB	05/24/88	1800	2.0 U		
WSP-GW-18S	N	05/24/88	1840	2.9 8	4.0 UN R	4.0 UN R
WSP-GW-18S	8FS	05/24/88	1900	54.6		
WSP-GW-190	N	05/24/88	0920	2.0 UW		
WSP-GW-19S	N	05/24/88	1015	2.0 UW		

NOTES: 1) Units are ug/L unless otherwise noted.

2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, 8FS = blind field standard, WB = water blank, BB = bottle blank.

3) Data-quality analysis codes are defined as: < = less than detection, 8 = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met. W = post digestion spike for furnace AA was not within control limits.

4) Blank values indicate parameters not determined or not reported.



**ATTACHMENT F**







# Northern

Engineering  
and Testing, Inc.

## MEMORANDUM

1610 B Street  
P.O. Box 4699  
Helena, MT 59601  
(406) 443-5210

DATE: July 20, 1988

TO: John Lincoln  
CH2M HILL

FROM: Pat Dunlavy

RE: Warm Springs Ponds Groundwater Flow Calculations (Revised)

As you know, we recently completed two aquifer tests in the vicinity of the Warm Springs Ponds. These tests indicate permeabilities significantly higher than we had previously calculated from slug tests. This discrepancy is most likely due to better well development through pumping, combined with the effects of monitoring well construction and the relatively low stress placed on the aquifer during a slug test. We feel the pumping tests provide more accurate aquifer characteristics than the slug tests. Therefore, we have reevaluated groundwater flow rates previously described in the Technical Memorandum dated May 19, 1988.

This memorandum documents revised calculations for groundwater flow rates along the two downgradient boundaries of the Warm Springs Ponds (the western geographic boundary along the Mill-Willow Bypass, and the northern geographic boundary below the Pond #1 berm). Also included in this memorandum are the results of calculations addressing the effects of flooding the two eastern cells of Pond 1 and groundwater cleanup rates for the area below Pond 1.

The total groundwater flow rates for each downgradient boundary do not change significantly. Rather, the assumptions used to evaluate each area, and our overall understanding of the groundwater system in the vicinity of the treatment ponds has changed.

### Mill-Willow Bypass Calculations

Groundwater inflow rates to the Mill-Willow bypass channel are required to properly design a drain to prevent the seepage of contaminated groundwater into the channel. This evaluation must be considered for both present day conditions and post drain emplacement conditions. Since water in the treatment ponds to the east is a source of constant head, emplacement of a drain to some depth below the present bypass channel may steepen the gradient, resulting in an increase in groundwater flow rates.



Our previous calculations addressing total groundwater inflow to the Mill-Willow Bypass were verified with seepage run data collected during the Phase I RI. An increase of two to four cubic feet per second (cfs) was measured in the bypass channel. This increase occurred from the upper end of Pond 3 to the confluence of the Pond 2 discharge. This rate was in agreement with our analytical calculations using a hydraulic conductivity of 400 gpd/ft<sup>2</sup> (55 ft/day), calculated from slug tests in monitoring well WSP-GW-07S. The reason our analytical calculation was in agreement with seepage run data was because we used an effective depth of ten feet below stream stage as the point where all groundwater to that depth enters the bypass channel. This is a case of adjusting assumptions to match measured rates.

We recently conducted a pumping test on monitoring well WSP-GW-07S, indicating a hydraulic conductivity of 2000 gpd/ft<sup>2</sup> (270 feet/day), located adjacent to the Mill-Willow Bypass. Results of this test were nearly five times higher than the slug test results. Consequently, using this higher hydraulic conductivity in the same calculations with the same assumptions, a total groundwater inflow to the bypass channel would be on the order of 15 cfs, which of course is too high. Therefore we adjusted our assumptions as follows:

- o Groundwater flow in the vicinity of the Mill-Willow Bypass moves horizontally.
- o Calculations assume an effective depth of groundwater inflow to the Bypass channel of one foot below stream stage.
- o Water level measurements used in the calculations are representative of long-term conditions.
- o The aquifer is homogeneous.

Based on the assumed effective depth of groundwater inflow to the bypass channel of one foot, and an overall hydraulic conductivity of 270 feet/day, revised seepage calculations result in a total groundwater inflow from both sides of the channel of 2.7 cfs. This value is in close agreement with the 3 cfs increase measured during the Phase I RI. An effective depth of one foot means that all the groundwater entering the bypass channel enters through the adjacent streambank. This assumption makes more sense than using effective depth of groundwater interception of ten feet.

AMC has recently constructed a dam in the Mill-Willow Bypass, diverting all surface flow into Pond 3 at the north Opportunity Pond discharge. Consequently, Mill-Willow Bypass is almost dry immediately below the diversion dam. The diversion dam has created an excellent opportunity to measure groundwater inflow to the bypass channel.





On July 11, 1988 we conducted a seepage run along the Mill-Willow bypass, resulting in groundwater seepage rates to the bypass of 2.6 cfs. This rate supports earlier seepage run data and our current analytical calculations.

Surface water flow rates measured in the bypass channel on July 11 are shown on Figure 1. On a unit rate basis, it appears the greatest input occurs along the upper reach of Pond 3, from the diversion dam to station SS-18C1. The least groundwater input occurs along the reach from SS-18C1 to SS-18D, where the head from water in Pond 3 to the channel is the greatest. This indicates that the head loss through the pond bottom sediments and berm are sufficient to negate the effects of a greater head driving groundwater into the channel. This phenomenon is further supported by examining the various gradients further downstream along the bypass channel. Groundwater gradients measured from the monitoring wells to the channel are all very similar, whereas gradients from ponded water to the channel varies from 5% to 24%. The average groundwater gradient measured from monitoring wells to the bypass channel is 2.4%.

Using the average gradient of 2.4% along the entire reach of Mill-Willow, and a hydraulic conductivity of 270 feet/day, a total groundwater inflow rate from the Warm Springs side to the channel is 2.5 cfs. This rate is also in close agreement with seepage run data. A unit input rate for groundwater inflow to the bypass channel is approximately 0.2 cfs/1000 ft.

If the treatment ponds to the east of the bypass channel are a true constant head source, then the emplacement of a drain at some depth below the present day channel will create a steeper gradient to the drain, resulting in increased flow of groundwater. Table 1 lists groundwater flow rates resulting from a single drain, emplaced at various depths beneath the bypass channel, if the present day constant head at the western edge of the pond system is maintained.

From Table 1, it appears that a significant increase in groundwater inflow is possible if the treatment ponds are a true constant head source. It is also possible that the head drop across the pond berms and through the pond bottom sediments is great enough to negate the effects of this gradient increase. However, there is presently insufficient data to support this theory. Therefore, we suggest performing your preliminary design calculations for the installation of two drains at a depth of one to two feet at either side of the channel. This would minimize the potential for an increase in inflow rates, and would insure capturing all groundwater before entering the channel.





#### Pond 1 Calculations

Our previous calculations for groundwater flow rates beneath the Pond 1 berm were also based on slug test data. Conservative calculations used previously included a hydraulic conductivity of 200 gpd/ft<sup>2</sup> (26 ft/day). The recently completed aquifer test performed in well WS-PW-01 indicates hydraulic conductivities ranging from 340 gpd/ft<sup>2</sup> to 770 gpd/ft<sup>2</sup> (45 ft/day to 102 ft/day). The high hydraulic conductivity value was calculated from the early (first 100 minutes) data, while the lower hydraulic conductivity was calculated from the late data. The drawdown curve for this pumping test indicates a negative boundary was encountered. This type of curve is common in unconfined aquifers where discontinuous gravel channels are deposited. Once the highly permeable gravel channels were dewatered, the aquifer exhibited hydraulic conductivities slightly higher than previously collected slug test data.

When evaluating groundwater flow rates to a dewatering trench, the highly permeable gravel channels would be drained fairly rapidly, then the aquifer would yield water dependent on the later hydraulic conductivity. For this reason, our revised calculations are based on a hydraulic conductivity of 45 ft/day. We have recalculated groundwater flow rates for a dewatering trench excavated to a depth of 20 feet and 15 feet. The total amount of water required to be pumped from a trench dewatered to 20 and 15 feet is 2.3 cfs and 1.1 cfs respectively.

These values are not significantly higher than those previously calculated. An advantage of the higher permeability is that the downgradient influence of such a dewatering trench would be slightly greater. The downgradient effective area of influence created by a dewatering trench to a depth of 20 feet and 15 feet is approximately 1800 and 1200 feet respectively.

An additional concern is the total time required to clean up the contaminated groundwater in the shallow alluvial system below Pond 1. For a conservative estimate, we have used a simple analytical calculation to estimate groundwater velocities induced from the dewatering trench. This calculation indicates a total clean up time of 670 days for a trench of 20 feet and 1340 days for a trench of 15 feet. Obviously, a dewatering trench excavated to 20 feet would create a larger gradient, accelerating groundwater removal. The contaminated groundwater escaping the dewatering trench's influence would continue to migrate north, ultimately surfacing in the Clark Fork River. The total time required for this water to migrate to the present day leading edge of the contaminant plume is approximately 7.5 years.



Our final evaluation concerns the downgradient effects resulting from flooding the two eastern cells of Pond 1. This calculation is mostly dependent upon the leakance rates of the tailings in Pond 1, and the head drop across the berm. If the eastern two cells of Pond 1 were flooded with one foot of standing water, we need to know if water leaking through the tailings would do so at a rate sufficient to increase the present day head on the alluvial system beneath the pond.

We used a numerical groundwater flow model<sup>2</sup> to examine these effects. Using a leakance permeability of 2 gpd/ft<sup>2</sup> for the tailings, a head increase of approximately eight feet would result on the alluvial aquifer. This head increase would result in a significant increase of water emanating from beneath Pond 1. It is difficult to accurately calculate this amount of increased groundwater flux that would seep through the berm, since there is very limited data. However, the current standing water at the eastern side of Pond 1 is a present day model for this scenario. Anaconda Minerals Company (AMC) intermittently pumps up to 1.5 cfs from the seep immediately below the eastern end of the Pond 1 berm. AMC has also stated that in the early 1970's, when the entire pond was flooded, the area below Pond 1 was extremely wet and discharge from the site was very difficult to control. For this reason, we feel flooding Pond 1 would significantly increase the volume of water entering the dewatering trench. Water quality data collected to date also indicate groundwater seeping through the eastern portion of the berm is the poorest quality groundwater in the entire area. It is our recommendation that any alternative which includes flooding Pond 1 be carefully evaluated.

### Conclusion

Recently completed aquifer tests on two wells indicate the shallow alluvial system in the vicinity of the Warm Springs Treatment Ponds is more permeable than previously calculated from slug test data. Consequently, groundwater flow rates for the area have been recalculated.

Groundwater entering the Mill-Willow bypass under present conditions is approximately 2.7 cfs. A groundwater drain emplaced beneath the present day channel may increase the local groundwater gradient such that groundwater inflow rates increase significantly. The tested inflow may be as great as 8.9 cfs for a drain set at three feet below the present day channel. A double-drain system should be considered to minimize the required depth and sizing for the drain, in order to intercept all the contaminated groundwater.





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The total groundwater flux emanating beneath the Pond 1 berm at depths of 15 and 20 feet is 1.1 cfs and 2.3 cfs respectively. An interception trench excavated to these depths would require the withdrawal of 2.2 to 4.6 cfs, respectively. The downgradient influence of a 15 and 20 foot interceptor trench is 1200 feet and 1800 feet, respectively.

The total amount of time required to remove all the downgradient contaminated water resulting from a 15 foot and 25 foot trench is approximately 1340 days and 670 days respectively.

It appears flooding the two easternmost cells of Pond 1 would have a significant impact on the volume of water emanating beneath the Pond 1 berm. Current water quality data also suggest an increase in metals concentrations in the groundwater would result. Consequently, flooding Pond 1 may not be an effective alternative.

Attachments

PD/jp

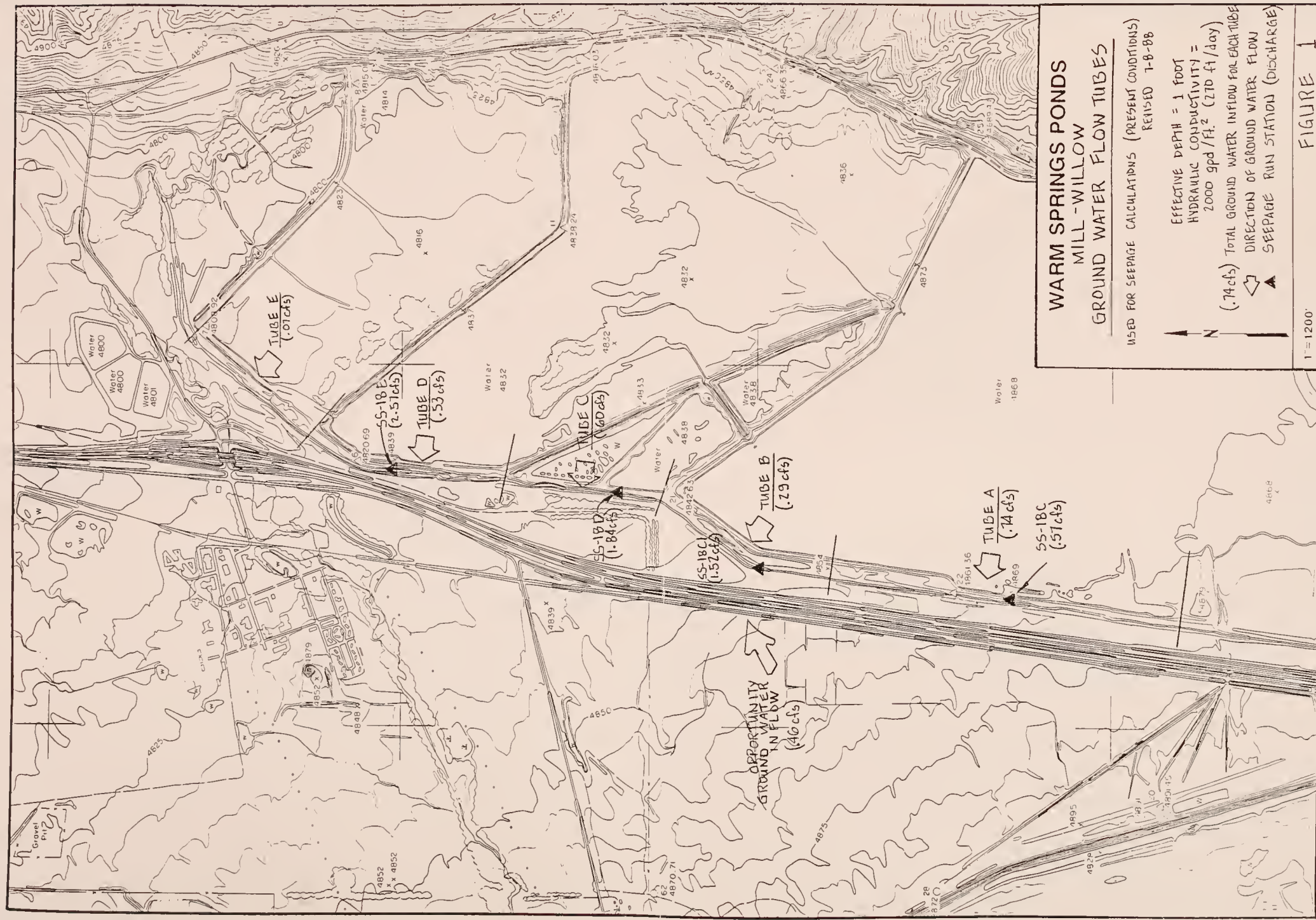


TABLE 1

GROUNDWATER INFLOW TO A DRAIN EMPLACED  
AT VARYING DEPTHS BENEATH THE MILL-WILLOW  
BYPASS (IF CONSTANT HEAD IS MAINTAINED  
AT WEST EDGE OF TREATMENT PONDS)

<u>Depth of Drain</u>	<u>Total Flow (cfs)</u>
Present Conditions	2.7 cfs
One Foot	4.5 cfs
Two Feet	6.7 cfs
Three Feet	8.9 cfs









**ATTACHMENT G**



# MILL/WILLOW BY-PASS - TAILINGS VOLUME SUMMARY

## Bare and Slightly Vegetated Tailings

<u>Location*</u>	<u>Area (ft<sup>2</sup>)</u>	<u>Thickness (ft)</u>	<u>Volume (ft<sup>3</sup>)</u>
	12,000	1	12,000
42	56,400	3	169,200
50	1,750	2	3,500
1-4	52,000	2	104,000
Diversion Channel			
4-5	33,200	3	99,600
Diversion Channel			
57	10,400	2	20,800
65	52,800	3	158,400
70	32,400	3.5	113,400
75	64,400	3	193,200
80	10,000	3	30,000
80	17,200	1.5	25,800
85	18,800	3.5	65,800
85	9,200	1.5	13,800
90-95	48,000	2.8	134,400
90-95	70,800	2.8	116,500
100-105	70,800	2	140,000
110-120	50,800	2	101,600
125-130	46,000	1	46,000
130-140	28,000	1.5	42,000
140-155	40,800	1.8	73,420
140-155	19,600	1.8	35,280
157-175	29,200	2	58,400
175-185	53,600	2	107,200
190-205	56,400	1.5	84,600
190-205	52,000	1.5	78,000
230-240	26,000	1	26,000
290-300	<u>94,000</u>	2-5	<u>235,000</u>
<b>TOTAL</b>	<b>1,027,350</b>		<b>2,287,900 ft<sup>3</sup></b> <b>84,700 yd<sup>3</sup></b>

## Vegetated Tailings

115	12,000	2	24,000
120	8,000	2	16,000
135	7,200	1.5	10,800
135	12,000	1.5	18,000
210	13,200	1	13,200
280-290	68,800	3.5	240,800
295-300	<u>95,200</u>	3.5	<u>333,200</u>
<b>TOTAL</b>	<b>216,400</b>		<b>656,000 ft<sup>3</sup></b> <b>24,296 yd<sup>3</sup></b>

\* Locations shown on Figure 5-2





## ATTACHMENT H



TABLE 5-5  
SUMMARY OF XRF INDEX VALUES AND LABORATORY CONCENTRATIONS  
OF SELECTED ELEMENTS IN EXPOSED TAILINGS/CONTAMINATED SOILS (Validated Data)

	Copper			Zinc			Arsenic			Iron		
	XRF Index (x100)	Lab Concentration (mg/kg)	XRF Index (x100)	Lab Concentration (mg/kg)	XRF Index (x100)	Lab Concentration (mg/kg)	XRF Index (x100)	Lab Concentration (mg/kg)	XRF Index (x100)	Lab Concentration (mg/kg)	XRF Index (x100)	Lab Concentration (mg/kg)
	36	730	30	415	46	461	168	25500				
	59	2330	40	3110	57	161	101	54800				
	43	1130	36	956	42	180	165	39100				
	142	8790	181	11100	70	211	348	132000				
	36	523	37	1150	46	121	66	12400				
	45	1370	38	862	45	220	146	35200				
	81	3440	79	3320	53	335	279	57300				
	58	2920	44	454	50	229	292	45500				
	50	1920	38	995	44	170	258	63600				
	46	572	33	381	52	311	255	47700				
	68	783	90	8540	49	474	178	13800				
	44	1790	47	2580	49	191	64	16100				
	115	8340	127	9120	85	1300	120	21900				
	117	11300	104	2590	40	147	128	22000				

CORRELATION EQUATIONS

Element	Equation		Correlation Coefficient (R)
Copper	Lab Concentration = (95.9)(XRF Index Value) - 3160		.96
Zinc	Lab Concentration = (72)(XRF Index Value) - 1498		.95
Arsenic	Lab Concentration = (18.7)(XRF Index Value) - 653		.86
Iron	Lab Concentration = (246)(XRF Index Value) - 424		.84

Notes:

1. Lab concentrations in mg/kg
2. XRF Index Values in Correlation Equations are x 100





